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THE EVOLUTION OF ARTIFICIAL INTELLIGENCE AND EXPERT COMPUTER SYSTEMS IN THE ARMY

A thesis presented to the Faculty of the U.S. Army Command and General Staff College in partial fulfillment of the requirement for the degree

MASTER OF MILITARY ART AND SCIENCE

by

Rickey L. Hanson, CPT, USA
B.B.A., Augusta College
1987

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This study is an analysis of the evolution of artificial intelligence and expert computer systems in the U.S. Army and the role the Army should play in the future evolution of these technologies. This study investigates the Army's approach to the development and use of these computer sytstems. It will assess whether the Army should play a leadership or a follower role in the development of these systems. The Army's decision to either lead or follow in these technologies will have significant effects on the limited resources of tomorrows smaller and less resourced force. This study will examine these issues given the trend in reduced fiscal resources and personnel. The civilian sector's development and use of these systems are evaluated to determine benefits to the Army through the use of these systems. The adaptability of these systems to various Army requirements are evaluated as are the near and far term costs of of these systems. This study concludes that the U.S. Army should play a follower role in the future evolution of both expert computer systems and artificail intelligence. The Army should exploit current technologies and help guide the civilian community in the research and development of military applications.

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The opinions and conclusions expressed herein are those of the student author and do not necessarily represent the views of the U.S. Army Command and General Staff College or any other governmental agency. (References to this study should include the foregoing statement.)

ABSTRACT

THE EVOLUTION OF ARTIFICIAL INTELLIGENCE AND EXPERT COMPUTER SYSTEMS IN THE ARMY, by Captain Rickey L. Hanson, USA, 141 pages.

This study is an analysis of the evolution of artificial intelligence and expert computer systems in the U.S. Army and the role the Army should play in the future evolution of these technologies.

This study investigates the Army's approach to the development and use of these computer systems. It will assess whether the Army should play a leadership or a follower role in the development of these systems.

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This study concludes that the U.S. Army should play a follower role in the future evolution of both expert computer systems and artificial intelligence. The Army should exploit current technologies and help guide the civilian community in the research and development of military applications.

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CHAPTER 1

INTRODUCTION

The revolution and evolution of computers in both the civilian and the military communities have been incredible. The difficulty comes in deciding how best to use the hardware and software available. This study will look at the evolution of computers from their inception, through their first military uses, through their present day military uses, and finally at possible future uses. This study will narrow the scope of the research to the evaluation of artificial intelligence and expert computer systems only.

This study will begin by looking at the field of computers from a user oriented prospectus. The information provided will not break new ground on the technical aspects of hardware or software engineering. Rather, it will review the beginnings of computers with specific attention paid to those areas where the military has played a role.

A major goal of this study is to identify current applications of artificial intelligence and expert computer systems, what the U.S. Army is currently doing in these

areas of research and development, and finally to determine the Army's leadership or follower role in the evolution of these technologies. The study will consider the overall system and not one particular peripheral in the evaluation of these technologies.

There exists today great anticipation and excitement in many sectors of the civilian and military communities when artificial intelligence and expert systems are discussed. Although it appears that technology is in the infancy stages of both types of development, there is sufficient evidence that demonstrates the explosive potential of both systems. Currently there are stock brokerages that use rule-based expert systems today to assist there clientele in the selection of stocks and bonds. Airlines use a rule-based expert systems to assign gates for aircraft and scheduling. There are expert systems available for home use to help parents diagnose their children. This system can also be used by doctors to check their own diagnosis and ensure a greater probability of accuracy the first time. There are systems to help in the maintenance of vehicles and the routes of long-haul truck companies. The lists of uses of these types of systems are large yet, this is only the beginning of their possible uses.

Everything is not as smooth as it may at first appear with both systems. Problems have occurred with both systems throughout their life cycle development that have at times slowed their development to nearly a halt. This is true in

both the civilian community and in the military sector as well. These systems much like other new systems, have had times of tremendous growth as well as periods where nothing new appeared to happen. Each time, however, as a new breakthrough in either hardware or software took place, these systems received a renewed sense of importance. The key to progress today and the future success of developments rests in steady, constant research in both of these fields.

Background

It is difficult to point to anyone in particular in history and state definitively that this person or that person is the father of the modern day computer. Some believe the Greeks had ideas of systems that could do various types of calculations. This paper will not add anything to this debate. Rather, it will begin with Charles Babbage's Analytical Engine.

Babbage was an unhealthy child in Somerset England in the early 1800s. Due to his poor health, much of his interests turned to the study of mathematics. As he entered Trinity college he found his tutors disappointing in the areas of mathematics. As an undergraduate, Babbage, John Hershel, and George Peacock founded the Analytical Society, promising each other to "do their best to leave the world wiser than they found it."[1] Babbage found himself drawn to various intellectual societies and was eventually involved

in the founding of the Royal Astronomical Society. Among his friends were Charles Darwin, Thomas Carlyle, Charles Dickens, Pierre Simon de Laplace, Sir Marc Isembard Brunel, Sir George Everest, and the Countess of Lovelace (Lord Byron's daughter), who, through her understanding of mathematics, machines, and the Babbage theories, has been able to pass on some of the most intelligible accounts of Babbage's work.[2]

Although Babbage never did build his Analytical Engine the design possessed many essential parts of the modern computer. The Analytical Machine would calculate, it would process statistics and would have the ability to guide its own actions based on the answers it was producing.

Babbage was about one hundred years ahead of his time in this area. The Analytical Machine's operation was based on a series of punch cards that would provide the machine information and then store it in the memory Babbage called "store." The machine was designed to run on steam.

By the early 1830s calculators began to be seen with Thomas de Colmar's Thomas Arithometer the most popular by 1850. During this time the Babbage Difference Machine built by George and Edward Scheutz in 1853 produced tables for navigation, insurance, and astronomy.

Through the remainder of the 1800s and into the beginning of the 1900's advances were made in these areas. By 1900 a statistics machine was in use by telephone

companies and railroad companies. Herman Hollerith's electric statistics machine was an electric adding mechanism incorporated into his tabulating equipment. This made it feasible for railroads to use punch card machines for their waybill statistics - what was shipped, who shipped it, who received it, how much it weighed, the shipping charges, and route taken.[3]

The first decision making system was developed by Leonardo Torres y Quevedo in the early 1900s. Leonardo Torres built what was probably the first decision - making automation - a chess - playing machine. Playing an end game with a rook and king against a human opponent's king, the machine would checkmate.[4]

It is during this period that the Army begins its interest in these machines. A problem the Army had during the World War I mobilization process was to determine how to put draftees into jobs and uniforms that fit them. During World War I the Army conducted a large scale application of psychological testing to decide the placement of these draftees. The process supplied masses of data, organized by punch card sorters, which were invaluable not only for the immediate problem but for later years. The Army's Alpha and Beta Tests were designed to discover special skills and leadership capabilities. They were also designed to identify recruits likely to be useless, or even dangerous, in battle. Alpha was given to literates, Beta to

illiterates. The results, coded on cards, were used to fill such specialized personnel needs as 105 scene painters for camouflage work, or 600 chauffeurs who spoke French. At the end of the war, the Medical Department of the Army measured 100,000 men to secured data for the making of new uniforms. The assembled information provided the first reliable picture of the size and weight of American men. Men from North Dakota had the largest chests, those from Alaska were the heaviest, and true to stereotype, Texans were the tallest.[5]

This was only the beginning of the Army's interest in the collection and processing of information. As the previous paragraph outlined, the Army was collecting and processing information for use in the following area: the decision making process, logistics, personnel, and the medical fields. The Army also began to see uses beyond these areas and began to encompass these technologies into the machines of war.

The introduction of new kinds of artillery and ammunition in World War I demanded new and more accurate ballistics tables. At the Army Proving Ground, at Aberdeen, Maryland, a group of university mathematicians were hastily assembled to apply scientific techniques to the preparation of precise gunnery tables. A young mathematician at Aberdeen, Norbert Wiener once wrote, "for many years after the . . . war, the overwhelming majority of significant

American mathematicians was to be found among those who had gone through the discipline of the Proving Ground." Wiener also remembers: "When we were not working on the noisy hand-computing machines which we knew as 'crashers' we were playing bridge together . . . using the same computing machines to record our scores."[6]

Work in these areas continued in both the military and civilian sectors throughout the early 1900s. As World War II was being waged, requests for wholly new ballistic tables (demanding the calculation of hundreds of trajectories for each table) were pouring into Aberdeen at a rate of six a day. A skilled person with a desk calculator could compute a single sixty-second trajectory in about twenty hours. The large differential analyzer produced the same result in fifteen minutes. The ENIAC (Electronic Numerical Integrator and Computer), when completed, would require just half the time of the projectile's flight - thirty seconds - to do the calculations. John W. Mauchly and J. Presper Eckert, Jr. of the Moore School, working with Captain Herman H. Goldstine of the U.S. Army, began planning the ENIAC in 1943, but the machine was not completed until after the war had ended. It was, however, widely used for scientific calculation until the early 1950s.[7]

Assumptions

1. Due to the continuing and rapid changes in the evolution of both artificial intelligence and expert computer systems, most of the information for this study will come from periodicals and experts within the military and civilian community.

2. That assessment of the cost of research and development can be determined in terms of financial, resource, and personnel costs. Additionally this information is presently available for consideration and comparison of statistical data.

3. That such technical information as required can be transferred at some cost to the military but all military technological research and development may not be as easily transferred to the civilian sector. This may be due to security or related reasons.

Purpose of the Thesis

The purpose of this thesis is to establish the U.S. Army's role in the research, development, and evolution of artificial intelligence and expert computer systems. It further will determine if the Army's role should be as a leader or a follower in the evolution of these technologies.

Definition of Terms

Artificial Intelligence. The subfield of computer science that endeavors to develop machines capable of performing functions normally associated with human intelligence, such as reasoning, learning, and understanding human language.[8]

Expert System. A computer program capable of considering a vast body of knowledge, reasoning, and then recommending a course of action.[9]

Inference Engine. The component of an expert system that accesses, selects, and executes previously programmed rules. Sometimes referred to as a rule interpreter.[10]

Knowledge Base. The part of an expert system that has declarative knowledge (facts) and procedural knowledge (rules).[11]

LISP (LISt Processing Language). The programming language used most in the United States for AI applications. LISP was developed in 1958; its name is derived from the listing of symbols emblematic of procedural and declarative knowledge.[12]

Natural-Language Processing. A subfield of AI whose goal is to develop an English-lanuage interface for computer systems.[13]

Symbolic Processing. The use of symbols or names to represent instructions. These names facilitate programming,

because words, rather than numbers, are used to refer to specific addresses.[14]

Significance of the Study

This thesis should assist the Army at all levels to better understand the options available and the conclusions found. This study will stimulate others within the military to reevaluate the Army's present situation and look forward into the future. This study will provide focus into the ideals of computer technology and the importance it will play in the smaller Army of the future; an army that must provide the same level of protection for our nation with far fewer resources. This gap can be made up through the use of systems such as these. The key will be to spend the limited resources in the right areas and prevent the duplication of effort of the civilian sector. This study will lay out, for the decision maker, the various options most important in determining the Army's role in the research, development, and evolution of artificial intelligence and expert computer systems.

Thesis outline

Chapter 2: Review of Literature. Artificial intelligence and expert computer systems are described as

they exist today in the military and civilian sectors. Their concepts for future development and applicability are also discussed in relationship to the cross use of these systems between the civilian community and the military. These issues begin with a historical overview of artificial intelligence and expert systems and evolve to a realistic view of our current status. This chapter will also look at the military's history of these systems and where the Army is today.

Chapter 3: Methodology. The review of historical and current literature in addition to and interviews with subject matter experts have provided the basis for the research of these subjects. The particular techniques used to implement this methodology is described later in this chapter.

Chapter 4: The Civilian Sector. This chapter discusses and analyzes the current status of development of artificial intelligence and expert systems. It provides an indepth look at the various directions of research and development in each field and possible future developments. This chapter will address the flexibility and adaptability of the two systems and evaluate the cost of the systems in terms of benefit.

Chapter 5: U.S. Army. This chapter like chapter 4, will discuss and analyze the current status of development of artificial intelligence and expert systems. Chapter 5, however, will provide an indepth look at the current status

of development of these two systems by the Army rather than the civilian sector. Additionally this chapter will look at the various directions of research and development in each field and the Army's plans for future developments. One such area of discussion is the Army's Eagle project. The chapter will conclude with a discussion of the available resources for research and development as well as the investment required by the Army in personnel, equipment, and money.

Chapter 6: Conclusions and Recommendations. This chapter focuses on the parallel development of the artificial intelligence and expert computer systems by the civilian sector and the military and how the two can be combined to the mutual benefit of both.

CHAPTER 1 ENDNOTES

1. Staples, Robert. A Computer Perspective, (Harvard University press, Cambridge, Mass, 1973) p. 12.

2. Ibid., 12.

3. Ibid., 47.

4. Ibid., 67.

5. Ibid., 76-77.

6. Ibid., 78.

7. Ibid., 133.

8. Shipley, Chris. "Whatever Happened to AI?", PC Computing, (March 1989): 66.

9. Ibid., 66.

10. Ibid.

11. Ibid.

12. Ibid.

13. Ibid.

14. Ibid.

CHAPTER 2

LITERATURE REVIEW

Given their rigor, reliability, and indefatigability, computers used as logic machines do extremely well what human beings do only poorly. For centuries the military has tried, without success, to discipline recruits to respond to precise commands and to follow rules without appeal to interpretation or judgment. And since the work of Frederick Taylor, factory workers have been subjected to a similar discipline. But despite the "rationalization" of work and its decomposition into precisely specifiable motions, and despite countless hours spent following preordained steps in rigid order, human beings never attain the precision of rule-following machines. Human beings, however, exhibit a flexibility, judgment, and intuition that resist decomposition into specification and inference and have proved equally difficult to instill logic machines. The question therefore is, given the best programming available now and in the foreseeable future, what level of skill can logic machines be expected to reach?[1]

The evolution and revolution of expert systems and artificial intelligence have not been easy and its critics are at all levels of our society. They cross all cultural boundaries as well as the boundaries of the military and civilian sector. It is only through a thorough search of the latest information and research that one can attempt to see through this cloud of information and misunderstanding.

It is curious though, as the evolution of these systems continues, that any success of these systems and the technologies are renamed leaving the name artificial intelligence as the graveyard for all of the unsolved mysteries. Perhaps the name itself is part of the problem with its reception by some. *Artificial intelligence.* The words have few, if any positive connotation. They are eerie. They have the feel of black arts and laboratory weirdness. "The term panders to a popular morbid curiosity of the grotesqueness and freakiness," says Jerrold Kaplan, president and CEO of the GO Corporation and former principle technologist at the Lotus Development corporation, where he coauthored Agenda, one of the few PC applications that uses programming tricks that have come out of artificial intelligence research.

To true believers, on the other hand, the words *artificial intelligence* ring of grand promises and fantastic dreams. They imbue the technology with genius far beyond its practical achievements and bring to mind robotic

companions that converse intelligently, protect their owners from harm, even brew and serve the morning coffee.

Of course, when the thunder dies, the smoke clears, and the screen is pulled away, artificial intelligence is none of these things. Certainly not yet and certainly not for a long, long time.

Like the Great Wizard revealed to disillusioned believers, artificial intelligence is much simpler and much more real. And it most certainly ought to be known by another name.[2]

There are many books available today that provide excellent historical points of view. One will notice the use of historical points of view. With respect to these systems, books provide a background for the fundamental understanding of the systems as they existed at that particular point in time. One such book is <u>A Computer Perspective</u>. It provides a very good historical review of computers in general. It provides a review from the beginning of concepts through the evolution of modern computers. It also provides some good insight into the Army's early involvement in the field of computers.

Hubert and Stuart Dreyfus have written a book called, <u>Mind over Machine, The Power of Human Intuition and Expertise in the Era of the Computer</u>.[4] In their book the Dreyfus's evaluate artificial intelligence and provide some insight into the difference between myth and fact. They

also provide a good fundamental understanding of expert systems and their emergence into the work place and into universities. Artificial Intelligence, An Applications-oriented Approach[5] by Daniel Schutzer provides one with definitions, history, theories, concepts, and examples of how artificial intelligence is presently used and possible uses in the future.

Although these books, as do many others, provide one with a good assortment of information on artificial intelligence and expert computer systems, the key to this research is in the most current articles available. As these systems evolve at a quickening pace the leading edge of the technology comes from periodicals and industry technical manuals. It is from these areas that most of the current information for this study will come.

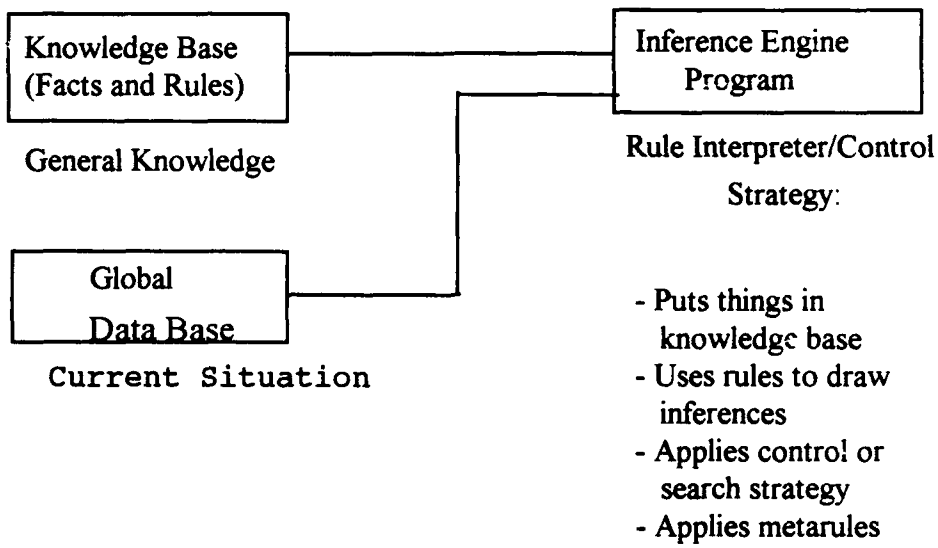
Artificial Intelligence

Artificial intelligence is a field of study concerned with designing and programming machines to accomplish tasks that people accomplish using their intelligence. Artificial intelligence also attempts to understand how human beings think, by studying the behavior of machine designs and programs that model current hypotheses and conjectures about some aspect of the human cognitive process. Thus stated, this field of endeavor is almost as old as the human species.

Many attempts have been made to define and demonstrate more precisely what is meant by artificial intelligence. Turing (1963) proposed the following test of machine intelligence: if a person engaged in a typewritten discourse with a machine hidden behind a curtain could not determine whether the conversation was with another person or with a machine could be said to exhibit intelligence. Early artificial intelligence programs addressed this challenge with mixed success. Another attempt to demonstrate machine intelligence involved programming a computer to solve portions of an IQ test. The attempt to define what behavioral characteristics a machine must possess to be considered intelligent, however, is best considered as an evolutionary process; advances in machine intelligence often result in more exact definition of

intelligent behavior.[6]

A GENERIC A.I. SYSTEM



ATTRIBUTES OF GENERIC A.I. SYSTEM
- Flexibility -- facts can be used more than one way
- Generality -- any fact or rule can be encoded
- Additivity -- program can evolve easily; new facts and rules can just be tossed in; order not important; hooks not needed
- Explanation faility -- line of reasoning can be displayed ("transparent" reasoning)

In artificial intelligence systems, program control is generally not a predefined, step-by-step procedure in which order is important. It is more of a trial-and-error procedure in which searches are made of a space of candidate

solutions, and heuristics are used to prune the combinational growth that occurs in most complex real-world problem searches. The inference engine applies the control of search strategy; it determines when to apply which rules against what part of the data base to produce an output or to reach a goal or conclusion. This strategy is often expressed by heuristic rules of thumb that are pattern-invoked, triggered by the specifics of the problem state, called metarules.[7]

The history of artificial intelligence is over forty years old, far older than most people would have imagined. The history has been an up and down roller coaster of advances and declines. During the 1950s some of the most important artificial intelligence developments were the chess playing program, the General Problem Solver, and the development of the computer language LISP. The LISP computer language is still the artificial intelligence programer's language of choice for most artificial intelligence researchers.

Advancement in the field of artificial intelligence continued through the 1960s and 1970s with continued enthusiasm. Advances during this period included the following: the first artificial intelligence computer controlled robot by G.W. Ernst, (it had a mechanical arm with a shoulder and grabber); continued research on the chess playing game; and the beginning of the first

commercial uses of artificial intelligence. It is in the late 1970s and early 1980s that one sees the first commercialization of artificial intelligence products such as the ACE -- telephone cable fault diagnosis; built by Bell Telephone and Columbia University.[8]

It has always been the hope of artificial intelligence researchers to develop a method for the computer to analyze a problem and find a solution much in the same method of the human brain. This is a difficult task, some say impossible, yet, work still continues on Neural network models. The difficulty in this attempt to copy brain functions may rest in the complexities of possible inputs and the limitations of our present hardware technology. An example of the multitude of the task is best explained as follows. The human brain has about forty billion neurons (a neuron can be thought of as representing approximately 1 byte of information), whereas today's computers typically have about two million bytes (2M bytes) for personal microcomputers to several hundred million bytes for large mainframes. Since we believe that decision making, learning, and other "intelligence-oriented" functions use only a comparatively small percentage of the brain's total capacity--typically ten to thirty percent--the equivalent of only about ten billion bytes (10G bytes) of neural memory probably are available to a human being for intelligence- oriented functions. This, however, represents a far greater capacity

than that of today's computers. Moreover, each neuron has from one thousand to ten thousand inputs and outputs, with over one hundred trillion interconnections. By contrast, today's computer components are relatively sparsely interconnected, with no more than four inputs per logic gates.[9]

It has been said that if you put the evolution of artificial intelligence on the evolutionary scale it would be somewhere at the same level as a roach. This is not to say that the idea will never get better or that artificial intelligence has no place in the civilian or military communities because it does. The process of research and product adaptability will continue to be a slow, but never-the-less a steady process and a necessary one as well.

There is always a cost associated with the development of any product. The value of the product must eventually pay for the initial research and development stages as well as associated production and upgrade costs. It is only now that artificial intelligence is beginning to bear fruit in this manner in the civilian sector. The artificial intelligence market today has grown from a $250 million business in 1982 to a $750 million business in 1985 and is projected to be more than a $4 billion industry by 1990, comprising 20-25 percent of the computer industry.[10]

To further amplify the quest of artificial intelligence the Japanese Ministry of International Trade and Industry

was to sponsor an ambitious development of the so-called fifth-generation computers. About $500 million were to be spent over a decade with the purpose of developing 'intelligent' computers for the 1990s and beyond, computers that would be able to understand natural language, to learn, to associate, to make decisions and to take action.[11]

The civilian sector is advancing in the use of artificial intelligence systems in almost every sector of the society. Automobile manufacturing has employed the use of robotics on their assembly lines. These machines do a myriad of tasks from welding body parts to painting. These machines must be precise in their workmanship and artificial intelligence has gone a long way in helping these changes take place. Rockwell International uses robots on their assembly lines to move component parts from one part of their plants to another. These are only several examples of many uses of artificial intelligence technology used in U.S. industry today.

Expert Systems

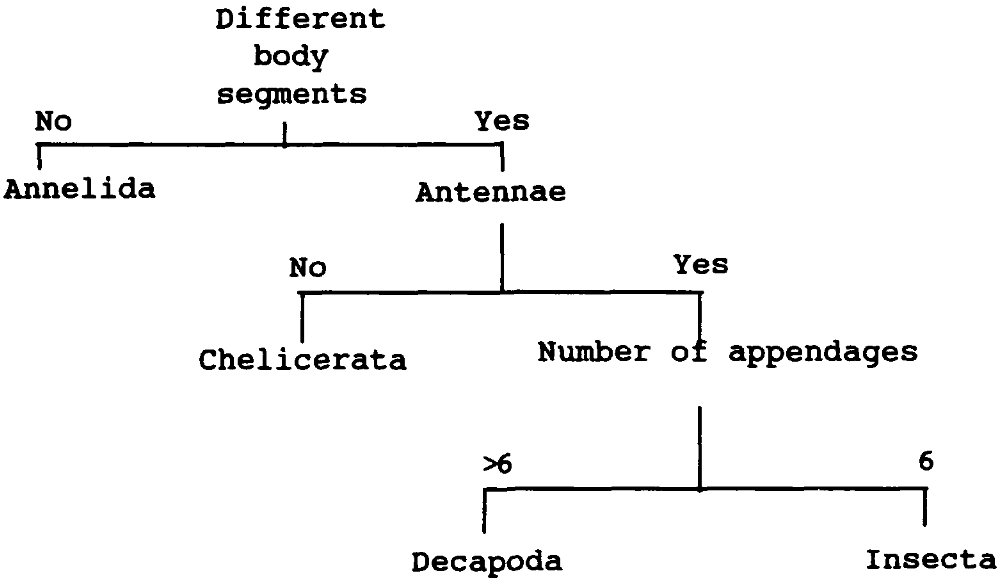
In artificial intelligence, many of the most well known techniques deal with some type of classification of data. In classification, the goal is to identify the category of class to which an object belongs. It is assumed that the possible categories are known before classification begins. Methods commonly used for classification includes rule-based

expert systems, induction systems, neural networks, and genetic algorithms. In a rule-based system, you construct a decision system that represents the understanding of an expert. This knowledge either is already well defined or is massaged into an orderly structure by knowledge engineering. Many expert systems are based implicitly on decision trees.

It's easy to see how the decision-tree model follows the classical theory of categories. Each leaf of the tree is a category -- a bucket into which you place classified objects. Membership in the category is based solely on properties that the objects in the bucket share. For example, in the tree shown in the following figure, membership in the category *Insecta* is determined solely by the presence of antennae and six appendages.

This representation suggests that for each of these objects, the properties describing them and their categories are well-defined "things" that exist in the "real world." Membership in the final category is an all-or-nothing proposition. No objects are better or worse members of the category.[12]

A RULE-BASED DECISION TREE



With rule-based systems, you often classify objects The limitation of such a system is that the structur categories available.

The figure above provides a simplistic example of the manner in which one type of expert system might work. The key to the expert system is the formulation of precise categories from which to test the information. The

construction of expert systems are very labor intensive as the programer attempts to categorize all possible information. One method programers are attempting to use is to construct methods from which the computer can learn from. Once this is achieved the system can help in the categorization of information within the database.

As society finds itself in an ever increasing information age, the chances for information overload becomes greater. Consider the inputs one person may be subjected to in an office environment. The telephones are ringing, the smell of coffee is present in the air, someone is smoking in the room, people are walking throughout the office, several conversations are taking place, computers and printers are running, copying machines and fax machines are operating, papers are shuffled, sirens can be heard outside, secretaries are greeting visitors, a fluorescent bulb is flickering in the ceiling, and the Sun is shining in your eyes. These and hundreds of other things are happening every moment of everyday and yet work must be done in the most efficient manner possible.

This appears to be a Herculean task just given the considerable sight, sound, smell, and touching sensations in the office. Add to this commotion the office manager entering the office with a series of new tasks to be preformed immediately. There are many tasks that appear to be incidental that might be better given to a real-time expert system. Real-time computer systems, which are

showing up in a growing number of industries and military applications show great promise for the future.

The Army's Computer History

The Army's involvement in the evolution of computers is as old as the technology itself. As outlined earlier the Army's interest started with the production of ballistic tables for the Artillery. During World War I the Army attempted to determine jobs for new draftees and uniforms to fit them. Initially the use of these systems was slow until the benefits became apparent. An excellent example of the benefit to the Army was in the area of ballistic tables. It used to take days to produce the projection of one or two types of artillery shell. With the arrival of the computer these tables were completed in hours rather than days. During this period of time the computer was little more than a calculator but the impact was still very great and provided the Army with a faster method to complete these tables.

During World War II the ENIAC computer was developed and used to a small degree. Although it was developed in 1943, it was never much use to the Army until the 1950's when the potential uses of the system were seen. The ENIAC was the developed by three individuals, one of them an Army Captain.

At the end of World War II the promise of digital computing had excited the civilian and military community as well. The U.S. Army Signal Corps played a significant role in the future development, testing and utilization of these new computers. Harold (Hal) Silverstein, special assistant to the chief signal officer in the Pentagon at the time, recalls that "the whole EDP program was charged up, exciting, and achieved extraordinary results in a short time. . . . We were a happy band of warriors, trusting in each other . . . a verbal request or a handshake was a binding commitment."[13]

During the mid 1950's the Signal Corps decided to take a separate path from those of the Ordnance and Adjutant General Corps. These two branches saw the use of the ENIAC and EDVAC more as just large calculators. The Ordnance Corps was interested in the production of ballistic tables and the Adjutant General's Corps was most interested in the accounting abilities of these systems. The Signal Corps saw different uses for these systems and turned their research to other areas. The Signal Corps had seen how the British used the Colossus computer during World War II to intercept communications. The Colossus was the first operational electronic computer; a classified cryptographic machine that analyzed communication intercepts. The Signal Corps saw a very close connection between the use of computers and

communications. This included both the tactical and nontactical uses of computers.

A turf battle soon emerged between the Signal Corps and the Ordnance Corps over the proponency of computers with officers on both sides disagreeing on the future uses of computers. The argument was finally resolved after a task force studied the issues and divided the responsibilities between the two branches. The Ordnance Corps was given the responsibility for all special purpose computers that were integral parts of weapon systems. The Signal Corps was given the functions of research and development, procurement, supply, career development, operations, and training for general purpose computers and associated peripheral equipment.[14]

In 1955 the chief signal officer requested the commanding general of the Continental Army Command to sponsor and jointly undertake development of military requirements, concepts of equipment, and applications development for EDT for combat and combat-support functions for the Field Army.[15] This lead to the development of the fieldata program.

To further develop these computer systems the Signal Corps requested a proving grounds to provide for future research and development of communications and computers. This lead to the opening of the Army Electronic Proving Grounds at Fort Huachuca, Arizona. During this period many

of the other branches soon began to see the advantages of computers as they relate to their specialties and began to organize and develop separate research facilities. Soon over 100 separate studies existed from Combat Intelligence to the Integrated Army Air Defense System. These systems were being studied by the Signal Corps, the Ordnance Corps, and groups at the Command and General Staff College.

Most of the systems were developing the operational know-how of the emerging technology while the Signal Corps fieldata program was beginning to take shape. The fieldata system had developed methods of transmitting messages and data over communications systems that could be interchanged. It was at this time the Signal Corps was recommending standards for computer hardware and software. This was a very ambitious step at this time considering the various programs that were being developed and tested at this time.

The work on the fieldata program was temporarily halted during the Korean war and resumed at its conclusion. The Fieldata program was permanently halted in the early 1960s as Vietnam began to escalate. Although the fieldata program was halted during the 1960s the research on computers continued, to a more limited degree, with each branch continuing to provide research and development of computers for those systems particular to their specific needs.

During the 1970s, 1980s through to 1991 the evolution of computers in the Army has continued to grow at an exponential rate. This fantastic growth has been spurred by the introduction of the PC and the ease of its use. The tremendous growth in the PC created great benefits to the Army through the increase of speed and efficiency it allows the user.

The PC has also created many barriers to progress. The most readily identifiable barrier is the incompatibility of hardware and software. As the civilian sector pushed past the military in the research and development of computers, the Army soon became a consumer of the product rather than a leader in the technology. With the follower or consumer role came several pitfalls with incompatibility being the greatest. As the PC was being developed each branch, with its specific requirements, was allowed to find "off-the-self" computers to help resolve their needs thereby reducing the Army's expenditures for research and development. Initially this concept was not a bad idea. Research time was approximately ten years from the identified need to the time the equipment was fielded. As computers changed very rapidly so did the software required to operate them. The Army soon found itself with pieces of equipment that had been purchased five to ten years prior without any replacement parts or if they existed, the old software was not compatible with the new replacement parts.

During the 1980s the Army was in the midst of a great

modernization and as a component of this modernization the computer became the key to success on the modern high tech battle field. At the end of the 1980s and into the 1990s, as the Army's budget was reduced, it soon became apparent that the compatibility issue was a serious problem.

The modernization process moved the Army well into the next century with the integration of computers and computerized systems. It soon became apparent that unless all of the separate systems were integrated, the Army would be left with intelligence systems that could not transmit information through the communications system. If it could transmit the information the system at the destination would probably not be able to receive or analyze the information due to either hardware or software incompatibility.

The greatest error in the off the self procurement process was the lack of coordination and standards for hardware and software. Had a system been in place to monitor and guide the Army in the procurement of computers the fixes that must be made today might not be necessary. The Army is not alone in this tragedy of incompatibility. The civilian community is in the same predicament the Army finds itself in with incompatibility between different word processors and spreadsheets.

There is however a very bright side to the explosion of the PC and that is in the development of artificial intelligence and expert computer systems. As the PC became more powerful through the advances in hardware technology,

it became easier for systems to be made for greater access to the Army and the civilian sector as well. A perfect example of this type of advancement is in the area expert computer shells. These shells offer the programer the basics of the system and do not require the programer to begin from scratch. Rather the programer can begin at the point where his specific information is required. These techniques have now become common place in the writing of expert systems in the Army and in the civilian sector as well.

Artificial intelligence research in the area neural networks has also greatly expanded due to the increased capabilities of the PC. It no longer requires the use of large mainframe computers to conduct this type of research. It can now be done with a PC in a stand alone configuration or within networks. This does not mean that large main frame computers are not required. They still play an important role in research and where large databases are required.

Perhaps the greatest contribution of the PC to the Army is the reduced cost of manpower needed to complete missions. Nothing in our history has made as great an impact on our Army as the computer has.

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CHAPTER 3

RESEARCH METHODOLOGY

This chapter reviews the approach used to determine the current technology available in the areas of artificial intelligence and expert computer systems as they relate to the U.S. Army. This chapter will discuss the research methodology used to determine the role the U.S. Army should play in the evolution of these computer systems.

INFORMATION SOURCES

The basic approach to this research began with a literary search for current material. The research then evolved into a search for the current status of development of artificial intelligence and expert systems within the military and civilian communities. The research concludes with personal interviews with experts in the military community.

RESEARCH TOOLS

The first phase of the research began with a review of material in the Combined Arms Research Library (CARL). The Combined Arms Research Library provided a very good starting place for the search of current books, magazines, periodicals, and studies on these two areas. The CARL has a wealth of information for research on literally thousands of topics. The CARL has a large collection of books to provide the basic understanding of the principles involved in the areas of computers, the history of computers, artificial intelligence, and expert systems. The CARL has a very comprehensive list of magazines, periodicals and studies available for use in the research of this topic. One method to determine the extent of research material available to one at the CARL is to access their computer data base. This is an excellent example of the Army's transition to computers. These systems reduce much of the time required to locate materials by categories. This system is setup in a very simple way to assist students in their search for material. There are four separate computer systems for the student to access and to help them to find a particular type of information or specific topic of interest.

The first system available provides one with access to books within the CARL. This is a simple database that allows searches by title, author, and subject. One need not

know the entire title, or subject as the computer will provide one with a list of possible titles. This same process is used for searches for books by an author's name. If one does not know the correct spelling of an author's name the computer will provide a list of possible authors. Through this method one can find the materials needed quickly and easily.

The CARL book search computer system also provides one with other important information on the material being researched. While researching books in the CARL system the computer provides one with the number of copies in the library, a list of other books in the library written by this author, a short synopsis of the books and if the books are available or checked out and the scheduled date for their return.

A second system available at the CARL is a computer database for magazines, and periodicals, and newspapers; much like the computer database that searches for books within the CARL. This database provides access to several thousand different periodical and newspapers. This system is similar to previous databases discussed but is best used when searching by subject rather than by author. This system provides one a search string to assist in finding all possible articles within the system. The system also prompts one to look in other areas for possible information on the topic. Like the book database this system provides a list of articles, a short synopsis of the article, and the

location of the article. These articles may be in paper form while others are provided in micro-fiche form. Those items on micro-fiche can be reviewed in the CARL on micro-fiche readers and printed copies can be produced.

A third system available to one in the CARL is information available on compact discs. This is a database of hundreds of thousands of books and periodicals available throughout the library system. Like the other databases one may search by author, title, or subject. One may also use a search string to narrow down the search. An example of a search string used in this research is "Artificial Intelligence, U.S. Army, Military". This allows the system to search for publications for anything in the title that may contain any combination of the three items listed. Through the use of these data search strings the articles found by this system decreased from forty-three thousands articles on artificial intelligence to thirty that contain information involving both artificial intelligence and U.S. Army.

A similar system is available on the second floor of the CARL for research centered on previous Master of Military Science Thesis and classified materials. The computer system is also a database available to the student identical to the book database. The search for previous Master's degree thesis is made simple in this way. Additionally, thesis from the Army War College and the Naval Post Graduate School are also available for research through

this system. If a thesis being researched is not available at the CARL, the library will purchase a copy and provide it to one to sign out usually within seven days.

In addition to all of the previously listed research information, the CARL has access to the inter-library loan system. This allows one access to research material not available within CARL. This system will normally provide one with the requested material within one to two weeks.

SELECTION OF SUBJECT MATTER EXPERTS

The selection of subject matter experts came from several different areas. Some were recommended by members of the research committee while others were recommend as a result of various other interviews to collect research materials. All experts have tremendous experience in the fields of artificial intelligence and expert systems. These individuals are in positions within their organizations that provide them the opportunity to guide research, to understand the management of their organization and those organization throughout the Army that do various types of research in these areas. These individuals also participate in the funding of the various projects they are associated with, making them knowledgeable of the future of artificial intelligence and expert systems. They all have insight into the future plans of the Army for their particular portion of the overall goal of the Army in the area of these

technologies. Finally all of these individuals now have or in the recent past have control of the direction that their particular organizations will take with regards to both expert computer systems and the other forms of artificial intelligence systems.

CHAPTER 4

CIVILIAN SECTOR

This chapter discusses and analyzes the current status of development of Artificial Intelligence and Expert Computer systems as they relate to the civilian sector. It provides a picture in time of the current status and development of these systems and how they are presently used. It reviews the flexibility and adaptability of these systems in terms of their possible use outside the perimeters for which they were built to include any military applications that might be possible. Finally it will discuss the production costs in historical terms through to the present and conclude with possible future costs of research and development.

CURRENT STATUS OF DEVELOPMENT

One of the biggest draw backs to Expert Computer systems has been the time required to achieve a result. Some systems required hours, days, and sometimes weeks to provide an answer to an inquiry. This posed many problems

for several industries that require their systems to be monitored and decisions made quickly based on the information provided. An example of a situation susceptible to operator overload is the control room of an oil-drilling platform, where an operator can be confronted with as many as 500 analog and 2500 digital signals. In the event of a system problem, this can result in a considerable cognitive load. And the problem is just getting worse. Future oil platforms will require that two or three operators monitor as many as 20,000 signals.[1] This problem also exists in many other types of industry such as the space industry, nuclear industry, and financial industry to name several. A solution to this problem has been the introduction of Real Time Expert systems. A Real-Time Expert System may best be defined as a system that responds to incoming data at a rate faster than it is arriving.[2]

Recently a few companies have developed specialized knowledge-based tools targeted specifically at the vertical real- time market. For example, the Talarian company, offers R*Time, a family of products optimized for intelligent monitoring and control. Like other real-time expert systems, R*Time has extended many of the traditional knowledge-representation methods to handle the real-time domain.

To achieve high performance and maximum modularity, R*Time breaks its major-tasks into three types of processes;

inference-engine processes, used to analyze dynamic data by means of objects, classes, and rules; data acquisition processes, used as links to the external world (these acquire, filter, and send the incoming sensor data to other processes); and human-machine-interface processes that provide point-and-click graphical user interfaces.

With a traditional expert-system shell, the inference engine, data acquisition, and user interface would all be grouped together into one large process, potentially tying up resources, such as memory and CPU, and making it difficult for the system to react quickly to critical events.

By breaking these key functions into independent processes, a real-time expert system can distribute its processes anywhere on a LAN and exploit the inherent asynchronous in the system to maximize throughput and response. Such a distributed architecture also has the advantage of being able to exploit multiple CPUs if performance requirements call for it.[3]

The use of real-time expert computer systems has great potential use across the entire civilian and military sector. An example of how this system can be utilized is in the area of nuclear power generation. As nuclear systems are proliferated throughout the world there exists a growing requirement for individuals able to monitor several thousands of inputs simultaneously and make the correct

decisions. These individuals are becoming more difficult to find.

Applying knowledge-based methods to real-time systems can result in many significant benefits, including reduced staffing levels, reduced need for the continuous presence of highly skilled operators, reduced training costs, increased safety, higher quality, higher throughput, less downtime, and more consistent, higher-quality monitoring.

The aerospace industry was one of the first to adapt expert-system technology to real-time problems. Today, artificial intelligence systems monitor such complex devices as the Hubble Space Telescope, NASA's space shuttle, the magellan space probe, and several military satellites. In almost all situations, the expert system acts as an adviser to a human operator who has ultimate responsibility for monitoring and controlling the vehicle.[4]

Real-time expert systems are now being installed as system monitors in many complex industries reducing the number of staff required to monitor and maintain these systems. Some examples of complexed systems now using this technology is NASA. NASA has employed the use of real-time expert systems to monitor the Hubble space telescope, the Space Shuttle, and Magellean satellite. These systems are also being used in water treatment facilities and other forms of industry requiring large amounts of monitoring.

In 1986 Lincoln National Reinsurance Company began exploring ways to use an expert computer system to assist the underwriters with mundane cases. Lincoln set up a committee to determine what their needs were and what the potential paybacks would be from such a system as this. As the committee began its investigation into expert computer systems it began to see the possibility of a greater link between their entire insurance business. They began to see the opportunity to tie the underwriters, the marketing department, and the client together in a long-term basis.

As part of the development stage of the expert system the Lincoln company had to identify the attributes of a successful project and incorporate these into the process.

In expert systems and other types of advanced information systems, there are two dimensions of complexity that are most relevant to development requirements.

The first of these is the complexity of the knowledge to be incorporated in or automated by the system. In expert systems, complexity is determined by fields of expertise - what knowledge engineers refer to as "domains." Systems that are highly complex in domains not only need input from business experts but also require that participation of knowledge engineers or systems analysts who also must have a high level of familiarity with the domain. They need to understand the science and terminology in order to effectively build the knowledge base.

The second basic dimension is the complexity of the technology. Factors that affect technological complexity include diversity of hardware and operating systems employed, data base access and networking, and the level of integration required Obviously, the higher the technclogical complexity, the more experienced and competent the programming staff must be.[5]

The success of Lincoln's project is not merely in the improvement in efficiency but in the effort the company went through. This process although very labor intensive up front pays for itself in the long term. A payoff goal set by Lincoln for this system was to reduce an underwriter's mortality claims by one percent. One percent may not sound like a great deal until one considers the size of the company and realizes that over time the savings can be tremendous.

William Will, president of Intelligent Planning Systems (IPS), Garden Grove, Calif., is using IntelliCorp's Prokappa expert-system shell to come up with Generative Process Planning for parts manufacturing. "It takes a part description out of CAD (Computer Aided Design) and issues instructions on how it should be manufactured," says Mr. Will. In effect, the system maps out a path whereby the part will be allocated to a certain machine or sequence of machines.

Mr. Will, who worked on artificial intelligence subjects for McDonnell Douglas Corp., explains that the premise of the system is to assist manufacturing by working out such variables as lowest tooling costs and cheapest materials.

It assumes the role of production planners who currently do this work in many plants. The difference is that the system does it faster and thus cuts down on time, a major element in the new manufacturing order. The principal target for the system is not the large-volume manufacturing market but companies that make products in small lot sizes.[6]

United Airlines is using a Texas Instruments developed Artificial Intelligence/Expert System to manage their gates at Chicago's O'Hare and Denver's Stapleton Airports. The new system, called Gate Assignment Display System (GADS), is designed to increase the effectiveness of United's gate controllers in assigning aircraft to gates in an attempt to reduce flight delays related to ground operations. United's system uses an artificial intelligence program that was created by drawing on the experience and knowledge of United's systems analysts and gate controllers through the process of knowledge engineering transfer. The program, or knowledge-based system, is driven by Texas Instruments Explorer symbolic processing workstations, which are designed for working problems that cannot be solved efficiently with traditional computing techniques. GADS

uses companion Raster Tech displays for hi-resolution, multiple-color graphic representations.[7] Additionally the system had input from United's Unimatic flight information data system, a computer system that tracks every United flight and all flight information.

The system that had been used by United previously was a staff of personnel constantly updating wall size charts with all of the important flight information. Considering that United had approximately eight hundred four daily arrivals and departures from fifty separate gates at Chicago's O'Hare International and approximately three hundred eighty arrivals and departures from twenty-seven separate gates at Denver's Stapleton airport, one can see how incredibly difficult is could be to monitor these flights. Consider the cost involved if two aircraft were sent to the same gate. The tangle of aircraft that would occur as the two aircraft attempted to determine which aircraft was authorized to use the gate. Passengers that all arrived at the same gate for two separate aircraft and luggage all moved to the same gate that would have to be separated and move to another gate. Consider the ground crews dilemma in trying to sort out all the confusion amid the hundreds of other flights arriving and departing from these two airports. Consider if this had happened during a Thanksgiving or Christmas holiday and the confusion and delays that could occur.

The old system used by United at these two airports was extremely dependent upon a small group of experts. These few people had great amounts of knowledge about their particular subject area but United did not have in place a system that could be tracked or changed rapidly.

GADS has eliminated totally the gate boar, and consequently the need to move around the room It also has incorporated the knowledge of the experts. The information that was shown on the board is now produced by GADS in a similar display on computer terminals.[8]

The system also permits the controller to try out different aircraft-gate combinations in dealing with problems that might come up before setting in motion a change gate plan. As the controller uses the mouse to move a flight from one gate to another, GADS will readjust the gate plan automatically so the controller can see the effects of any action.

"The gate controller now has the ability to play 'what if?' games," Wejman said. "In the past, we dealt with moment-by-moment changes; we didn't see how something would affect us five hours down the line."

"With GADS, we can avoid problems and conflicts before the problems happen."[9]

The most important component to the success of an Expert Computer system is not in the hardware or in the software but rather in the plan for development. If

corporations do not plan out the need for the system and the payoff, large corporations will not normally spend money on the development of systems such as these. The development of these systems, as has been demonstrated thus far, requires experts in the particular field the system is being designed for as well as a team of technical personnel that understand how the software must be written. Another example of industry taking the lead in the area of expert computer systems is the E.I. du Pont de Nemours & Company and Digital Equipment Corporation.

Five years ago, E.I. du Pont de Nemours & Co. opted to train its end users to develop their own small systems. Today, the more than 600 expert systems installed in DuPont's business units are cumulatively saving more than $75 million per year. By 1991, thesis expert systems program is expected to contribute more than $100 million annually to the bottom line.

Over the last 10 years, Digital Equipment Corp. has evolved an equally successful program following an entirely different strategy. To begin its expert system efforts organization, digital established the Artificial Intelligence Technology Center (AITC) in Marlborough, Mass. AITC has become a strategic resource for training highly skilled knowledge engineers. The result is a fast-growing number of operational and strategic systems affecting all its business processes. Digital now has 50 major expert

systems in place, contributing $200 million in annual savings.

DuPont and Digital share a fundamental expert systems goal: to improve decision making throughout the corporation by putting relevant information and knowledge into the hands of those making the decisions.[10]

DuPont has discovered that although expert computer systems can provide them with better efficiency and tremendous annual savings it is not a panacea. There are mistakes that are made and systems that do not work or do not provide a savings in manpower or money. These systems do not last long and soon are abandoned due to lack of use.

Just fifty systems have simply withered away at DuPont, while 600 have proven highly productive. DuPont's expert systems generally fall into one of the following area: troubleshooting and selection systems used from development to sales and delivery; production planning and scheduling; and remote process control.

Useful expert systems have been devised to help design products meeting specific customer needs For example, the Packaging Adviser, used for designing rigid plastic food containers, helped DuPont break into the highly competitive barrier resin market. The company also tackled a critical problem, chemical spills occurring in transit, by developing a Transportation Emergency Response Planner to guide people in the field through the right procedures for diagnosing,

controlling and cleaning up a spill. A Maintenance Finish Adviser is used at trade shows to answer questions on high-performance paints and obtain sales leads. And a Confidentiality Document Adviser is used for preparing sections of legal documents.

Expert systems are widely used throughout DuPont's manufacturing process for troubleshooting and quality control. So far, the company has developed 50 expert systems for diagnosing and correcting process control problems. A 600-rule expert system, built by two people in concert with the business team, has been integrated into one unit's production planning and scheduling system.[11]

FLEXIBILITY AND ADAPTABILITY

The flexibility and adaptability of the expert systems that exist within the civilian sector is easily seen in the way industry has developed them. The expert management systems are simple examples of the civilian market wanting systems that will allow for time consuming analysis to be conducted. Through the use of these systems the decision maker can be freed to do other things by allowing the expert systems to evaluate the information and then provide the decision maker with a recommendation to the problem based on the situation.

As industry's pace of production and efficiency must increase to remain competitive, decision makers no longer

have the luxury of time. These management expert systems are very good tools for the decision maker in that they can be adapted to just about any situation imaginable. This is made possible through the development and increased availability of expert computer shells. These expert computer shells provide the programer the basic written program and several examples of how the program can be adapted and rewritten. This saves large amounts of time for the programmer and the client as well. The process can begin with the expert providing information to the programer who writes the necessary code. This is also a great savings to the client who can purchase these expert shells, depending upon the complexity of the system required, for much less than the cost of having the programmer begin the process from scratch.

Near time expert systems such as those used by NASA to monitor the Hubble space telescope and other complexed satellites have been adapted for many other uses as well. These same types of systems have been used in the operation of water treatment facilities and other industries requiring large amounts of monitoring. These same systems are being considered for use in some large cities to assist in the operation of city departments. One such possible operation is the coordination of fire, police, and medical assistance. This system would allow a centralized facility to monitor all city vehicles and would ensure the correct organization was sent to the location required. The system would have

the continuous location of all vehicles and would be able to route the organization and vehicles best suited for the situation. These systems would provide for greater efficiency of operation and help to eliminate sending the wrong type of vehicles to a location. An additional benefit would be to the operator of the vehicle. The vehicle would have a small computer installed providing constant contact with the central facility. If the vehicle were to have a problem or make a wrong turn the system could immediately notify the operator and/or the central facility and make recommended corrections. This same system could provide expert medical assistance for emergency medical personnel or even assist a police officer in the emergency delivery of a child. This system would not replace the need for doctors but would rather assist the physicians might be otherwise committed with another emergency.

Although the system is currently possible and available today, the initial cost to setup the system in every city vehicle is somewhat prohibitive. An additional consideration is the training cost to the city for the operators of the system. The final consideration to this system is the cost of the computer itself and the expert software required. This is not to say that the system will not be used but rather to outline the barriers that presently exist. The good news is that as these systems become more available the cost will decrease. This is due to the adaptability of the system. Once the system is setup

in larger cities, the system can be adapted for use by smaller cities with only minor changes required.

In the area of neural network types of artificial intelligence the picture is not very clear nor is it at present very bright. Although certain advances in this area have been made there does not exist, at present, a system available that has any great commercial appeal. This is not an indictment of Neural Net systems but the current development has not progressed to the extent as expert systems. One large consideration in the development of any system is the usefulness of the research. Currently only small strides have been made in these areas. There is however, a great deal of research being conducted by many companies and university attempting to find uses for these types of systems.

PRODUCTIONS COSTS

As stated earlier industry looks to find products that provide a usefulness in the short run as does expert systems. To this end much of the money for research in many companies has been used to further the development of expert systems. Other forms of artificial intelligence such as neural networks, although they show the promise of great uses, have currently failed in an attempt to make them productive in the short run. It is therefore no mystery why expert systems have flourished so much in the past decade.

University research is another issue. Now that expert computer systems are flourishing many universities are doing work other forms of artificial intelligence such as neural nets and visual recognition. Each day some university appears to have discovered another piece of the pie as they attempt to develop a computer system that functions much like a human brain. Although the modeling for such a system is available in simple terms the complexity of the human brain still cannot be matched by any machine to date. The cost of this research is expensive but the burden can be shared by the taxpayer and industry as well. By assisting universities industry can benefit from the results of the research without having to foot the entire cost of the research themselves.

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CHAPTER 5

CURRENT STATUS OF DEVELOPMENT

Artificial intelligence and expert computer systems have become an important part of the Army to date and show great promise in the future. The greatest benefit to the Army has been in the area of expert computer systems. These systems are currently flourishing at all levels of the Army as the various branches of the Army discover the potential uses of these expert computer systems.

One of the expert systems currently under development by the U.S. Army Force Integration Support Agency is the Total Army ANalysis Knowledgebase (TAANK). TAANK is an intelligent decision support system that will function as an interface to analytical tools as well as to an integrated departmental database, and associated knowledgebase. TAANK consists of five component modules: a Data System module, and modules for Organization Integrators, Force Integrators, System Integrators, and Document Integrators. The Data System module will access all of the relevant databases and provide a means to correlate information from one database to another. The remaining modules will provide a user oriented graphical interface that will provide access to the

required data, as well as menu options that will invoke analytical processes as well as inferencing routines.[1]

The Army's Personnel Command (PERSCOM) is presently working on many types of expert systems. These systems will assist PERSCOM in managing the large numbers of soldiers currently in the Army, the acquisition of future recruits as well as the draw down of forces over the next five years.

One of PERSCOM's expert systems used is in the area of accessions. This system must consider the Army's need for new lieutenants by specialties and branches. The expert computer system provides recommendations for the distribution of accessions for a given year.[2] The system also runs continuation rate models. Additionally the system must consider the new lieutenants possible use as branch detailed officers and those positions available for grade substitutions.

Another expert system PERSCOM is presently using assists in the modeling of an Officer's career. The purpose of the system is to provide an army wide, 30 year continuation rates for the officer population by career managed fields (CMF), sex, ethnic group, readiness category (REDCAT), component, and source of commissioning. The system also provides statistical data for use in inventory projections modeling.[3]

An additional expert system used by PERSCOM assists in the branch detailing of new lieutenants. The use of this

system allows for the new officer to initially attend a combat arms branch from two to four years and then to be reassigned to the branch of their original choice, thus branch detailing. The expert system is called the Branch Detail Distribution System. The purpose of the this system is to determine a good distribution for branch detailed lieutenants under programs of varying detail periods, branch participation, and acceptable distribution characteristics. Lieutenant positions accounted for by branch (those participating in the detail program) and station (geographical location within which a move incurs no cost).[4] These requests for detail officers from the various branches are then input into the system. The system uses an algorithm that produces the best match possible for the Army and the lieutenant based on need, location, and career branch selected.

Expert computer systems are also finding usefulness in the medical field as well as in the other branches of the Army. One such use is for the detection of diseases. One of the U.S. Army Medical Research Institute for Infectious Diseases's projects is the Disease prediction by Remote Sensing of Environment. Outbreaks of Rift Valley Fever (RVF) disease in domestic animals in sub-Saharan Africa are clearly correlated with widespread and heavy rainfall. It is thought that this rainfall can flood mosquito breeding habitats, known in Kenya as "dambos." The goal of the

project is to use remotely sensed images to predict where these breeding grounds are. This information will be used to help military strategist determine the safest location to establish military camps and whether these soldiers should be vaccinated for RVF.

Currently, LANDSAT Thematic Mapper (TM) and SPOT images have been used in this study. Statistical analysis is being used to refine these techniques. Ground truth has increased the accuracy of supervised classification of dambos. Radar image technology is in place to augment this study.[5]

The United States Army Artificial Intelligence Center in the Pentagon is developing an executive decision aid expert computer program call the Single Army Battlefield Requirements Evaluator (SABRE). The SABRE is an integrated executive support system that provides a window for exploring the current and projected structure and condition of the Army. It consists of four component modules: FORCEMAPS, Fast Interactive Status Projections (FISP), SMART, and Force Closure. In FORCEMAPS, a user can interactively specify a context for viewing a force in terms of theater, operation plan, year, day of the war, or other criteria. The requested force structure is then graphically displayed using a tree diagram showing command relationships and a variety of user-selectable projected readiness condition indicators. Information displayed can be aggregated and displayed for different levels of detail A

variety of reports are also available. FISP provides a comparative display of projected unit readiness based on the programmed acquisition of new and existing systems. FISP also supports multiple ratings projection databases, allowing comparison of proposed reporting policies. SMART is a collection of graphically enhanced special reports that allow a user to compare forces or units and explore the projected modernization of units. Force Closure graphically depicts the flow of units into a theater as specified in applicable operation plans along with their projected readiness.[6]

One of the most promising group of systems available today is in the maintenance field. In the past a commander of an armor company might have to use tracked vehicle mechanics to assist in the repair of a wheeled vehicle or he might have to use a wheeled vehicle mechanic to help with the repair of a tank turret. These soldiers have all received specific training in their particular military skills area but due to circumstance beyond their control they must attempt to repair equipment not familiar to them. Through the use of an expert computer system, the mechanic can identify the fault more readily and also receive instructions on the repair of the item. The procedures before the expert system was one of guessing what was wrong and hoping one could determine the problem. These types of expert systems are currently in use by industry and the Army

is presently providing input for the production and distribution of these maintenance systems throughout the Army. The best by product is the ease of upgrading the databases of these expert systems. Rather than waiting for someone to write a new manual, send it to the printers for production and then pay for the mailing of the manuals, these expert systems may be upgradeable through the use of a modem. If the expert system required a floppy disk to do the update, the cost to mail it rather than an entire manual would save the government millions of dollars in postage alone.

The Battle Future Laboratories at Fort Leavenworth Kansas is doing work with the connectivity of various battlefield operating systems. One such project is the Airland Battle Management Advanced Technologies Transition Demonstration Program. It is attempting to build a series of mini expert computer systems for command and control purposes. The objective is to apply Airland Battle Management (ALBM) to refine operational user requirements for automated decision aids for planning. Additionally ALBM attempts to develop operational prototypes of decision aid applications to support training.[7] All of the Airland Battle Management Advanced Technologies Transition Demonstration Program prototypes are targeted for implementation on Army Common Hardware-Software (CHS). Success achieved in the Airland Battle Management Advanced

Technologies Transition Demonstration Program can be quickly transferred to Battlefield Functional Area nodes such as the Maneuver Control System (MCS), Advanced Field Artillery Tactical Data System (AFATDS), and to the Force Level control System (FLCS).[8]

PROJECT EAGLE

One of the Army's largest expert computer systems is the Eagle project. Eagle is a deterministic corps-level combat model with resolution at battalion level. It is intended to be used as a combat development tool for studying corps and division-level force effectiveness issues. The design goals of Eagle were to build a responsive system, through detailed simulation which modeled command and control (C^2) and depended on previous methods to model well-established processes such as attrition.[9] Eagle has been under development since 1988 by the TRADOC Analysis Center. Much of the work is currently being completed at Fort Leavenworth in building 93. The expert system is very complexed due to the extremely large amounts of data that must be analyzed by the system. Eagle was designed to assist in the combat development area. The system analyzes the force structure effectiveness as it relates to the various weapon systems, command and control, doctrine, and organizations.

One of the goals of the project was to allow a scenario to be established in days rather than in weeks and months as do many of the current systems available today. One of the critical elements to the success of the Eagle project is the incorporation of artificial intelligence and representation of the information. It is extremely important that the user and machine both have clear understanding of the uses of the various types of input available. These include but are not limited to a clear understanding of weapon systems, their capabilities, uses, and logistic requirements. This is also an important consideration for communications equipment, medical support, personnel replacements, and all forms of combat, combat support, and combat service support. Without this crucial understanding the solutions recommended would be skewed and be of little value. The eagle also has the ability for continual updating for such things as terrain with the use of a Terrain Processor which uses standard digitized Defense Mapping Agency 100-meter terrain data.[10]

One of the keys of success of the Eagle project is the infusion of current artificial intelligence technologies. Unlike other simulation models Eagle can adapt quickly to changing situations and varied scenario.

The Army continues work on other forms or artificial intelligence such as neural nets. This research much like the research and development in the civilian sector is slow in showing any short term benefit. Indeed advances have

taken place but to date there is little if any hope of neural nets technology providing the same possibilities as do expert systems. This does not mean that there is no effort in this area. The Army does have several institutions that do research in these areas. The amount of research conducted is difficult to determine since most of the effort, as in the civilian sector, is aimed at producing greater benefits from expert computer systems.

One of the areas currently under consideration for research and development is the Autonomous vehicle. The concept is for a vehicle with a weapon system on it to be dropped behind enemy lines. This system would be in constant communications with a central facility that would monitor the position of the vehicle and status of its systems. The vehicle could be given an individual mission or participate as part of a group of machines. Missions it could receive might be to destroy logistics centers, command and control facilities, to destroy bridges, or to harass and disrupt communications in the enemy's rear areas. These systems could also be remotely controlled as well as completely autonomous.

The significant hurdle that must be jumped is how to make the system think and reason as a human being. It is presently easily to have a weapon system transverse and hit a target. This has been demonstrated with many of the smart bombs such as the cruise missile system. It has not yet been demonstrated how a machine could identify a target,

engage it, and move on to the next or return to friendly areas. The difficulty comes in deciding which target has priority and can it be better engaged by a different weapon system. Additionally if working in a group a decision would have to be made as to which machine engaged the target. What would happen if one or more of the weapon systems were damaged and destroyed? New decisions would have to be made to reprioritize the missions and to reallocate the logistical supplies such as transferring of fuel and weapons from one vehicle to another. An additional consideration is the need for the weapon system to be able to assimilate information before firing a weapon. An example might be of a weapon system dropped behind enemy lines to destroy enemy tanks. The weapon system identifies an enemy tank and moves forward to engage the target. The target is a disabled tank and the crew have tied a white flag on the end of their radio antenna. The weapon system must collect all of the pertinent information about the enemy tank to include the flag and then determine whether to fire or not.

If the vehicle is remotely piloted and the driver is able to see the tank then the weapon systems artificial intelligence requirements is not nearly as critical. In this example the weapon system would merely make a recommendation to fire or not to fire and the pilot would then make the final decision concerning the disposition of the enemy tank.

Another system that has been under research and development for sometime is a vision recognition system. This system would provide the pilot of an army helicopter or a tank a recommendation on the type of vehicle it sees in the distance. This system has several sensory inputs and can be used over long distances depending on the sophistication of the input. If the input provided include satellite near real time input, then the distances for recognition can increase to the limits of the satellite foot print.

One such system has been under development at the Air Force Institute of Technology for several years. The system being research was on a sun computer system with the screen divided into four quadrants. In each of the quadrants was a different view of the same vehicle. One of the quadrants had a satellite picture of the vehicle, the second quadrant had a thermal picture of the vehicle and the third quadrant had an infra red picture of the same vehicle. The computer's fourth quadrant was separate from the rest of the system. In this quadrant the operator could see what piece of equipment was being displayed in the other three quadrants. The computer's mission was to correctly identify the equipment and to learn to see patterns. With the ultimate goal of being able to engage more targets at greater distances with fewer friendly casualties. As the system evaluated more and more images the probability that

the vehicle identified was correct increased to approximately ninety-five percent.

The problem that currently exists is with the computer's ability to correctly identify a vehicle in poor weather and with photos that are not very clear. The computer's ability to identify vehicles under these types of situations drops somewhere in the seventy percent range.

There are other systems under development that would allow for hazardous material to be moved by machine rather than by humans. There exists research on vehicles that can hot refuel aircraft without endangering any of the ground crew. These as well as other artificial intelligence systems are still sometime from becoming a viable way to replace humans.

AVAILABLE RESOURCES

The Army has a great deal of resources available for the research and development of these and other types of systems. One method is the research conducted by universities throughout the country. Another are the military schools such as the United States Military Academy at West Point, the Army detachment at the Air Force Institute of Technology and the United States Army Computer Science School at Fort Gordon, Georgia to list a few. Additionally there are separate laboratories, both military and civilian that do research for the Army and other services as well. The laboratories at LABCOM and Los Alamos

National Laboratories are two such laboratories. The Army also has access to the department of defense facilities and information. The physical resources are abundant and are not as great a problem as the shortfall in human resources. It is this shortfall in human resources and the reduced funding for these research projects that have created such a lag in the new development of these weapon systems.

INVESTMENT REQUIRED

As outlined earlier the cost of developing these systems is astronomical in terms of financial costs and human resources. The Japanese have made a national commitment to develop new artificial intelligence systems over the next ten years. The cost to the Army to keep pace may be more than can be calculated. This is in terms of the commitment of funds over the long run and the human research requirements.

Pure research unlike other types of design work requires hard work and a little luck. A researcher may work in an area for years and then realize that there is a flaw in the methodology and have to begin from square one. An example is attempting to train to time rather than to standards. If you train to the time you may not cover all of the material in the required depth. Much the same with pure research if something happens and the research does not provide any short term benefit the researcher must have the

latitude to continue. As the Army's portion of the budget continues to shrink so may the amount of financial resources available to invest in these types of technologies and pure forms of research.

CHAPTER 5 ENDNOTES

1. United States Army Information Paper, "TAANK-Total Army ANalysis Knowledge", Office of the Deputy Chief of Staffs for Operations and Plans, 1991.

2. United States Army Information Paper, "Accession Planning", Officer Distribution Division, Personnel Command, 1991.

3. United States Army Information Paper, "Continuation Rates", Officer Distribution Division, Personnel Command, 1991.

4. United States Army Information Paper, "Branch Detail Distribution System", Officer Distribution Division, Personnel Command, 1991.

5. United States Army Information Paper, "Disease Prediction by Remote Sensing of Environment", U.S. Army Medical Research Institute of Infectious Diseases, 1991.

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7. United States Army, Future Battle Laboratory, An Overview and Project Summary. Command and Control Directorate, Combined Arms Command, Combat Developments, United States Army Combined Arms Command, Fort Leavenworth, Kansas, June 1991. p. 13.

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CHAPTER 6

CONCLUSIONS AND RECOMMENDATIONS

The thrust of this study has been to determine the role the Army should plan in the evolution of expert computer systems and artificial intelligence. Should the role of the Army be one of leadership as it had during the early years of the ENIAC computer or should the Army be a follower of technology. Central to the conclusions of this study was the understanding of where the Army has been with regards to computers and their uses. One may not simply assume that the Army should take one path over the other by studying the proliferation of the personal computer and its use in the Army. This is not to say that the importance of the personal computer is not a factor to be considered. Rather it is a tool much like a hammer is to a carpenter. The hammer can be used to drive nails, to remove nails, to break cement bricks, and to adjust window frames. The personal computer, like the hammer, is also useful to the Army in many ways.

Much more important to the central understanding of the direction the Army should take in the future is the importance computers play in the every day uses of the Army.

These uses include weapon systems, communications systems, maintenance systems, hospitals, motor pools, warehouses, laundries, dining facilities, and in almost every component of the Army today. These systems originally were all autonomous in their operation and this served a purpose initially. The challenge that now exists is the incorporation of various systems into one overall architecture that can be upgraded to provide for new and more efficient software and hardware.

The key to the success of this challenge is the use of expert computer systems and artificial intelligence systems. Many of the components exist today that can and will assist in providing the Army with this overall information architecture. Many of these systems are in use in the civilian community or the military or in both and continue to show the promise of better utilization of personnel and scarce dollars.

CONCLUSIONS

In an effort to determine the direction the Army should take with regards to expert computer systems and artificial intelligence systems one must try to identify trends through the research and development community in the Army. As with any survey one will never find the yellow brick road to the land of Oz but it is possible to find a best fit line based on a consensus of opinion. To do this one must ask a series of questions. These questions provide a focus and therefore

a recommended direction can be determined through these topics.

As was stated earlier, artificial intelligence means many different things to different people. If one were to ask ten informed people to give a definition of what artificial intelligence is, one would most likely receive ten different responses. One thing that does appear to happen to technologies within the artificial intelligence arena, is the fact that once the technology becomes accepted and in use it is no longer considered under the artificial intelligence arena but comes under a separate title. Expert computer systems is an example of such a system that was originally, and arguably still is, under the umbrella of artificial intelligence.

The Army has in place a group of artificial intelligence cells through the various branches of service. One of the largest proponents is in the Training and Doctrine Command (TRADOC). Almost every branch school has an artificial intelligence cell working on branch specific projects. Many of the projects currently being worked are in the area of expert systems.

The first question one must address is where the Army is headed with expert systems. Expert systems may be written from shells or they may be developed from the ground up depending on the complexity of the project and whether or not a shell exists. These expert systems have proven to the Army leadership the great savings in personnel and resources

they can provide through their use. One of the keys to the success of the expert systems is the low cost to produce many of the systems and the ease of use to the individual soldier. Additionally, expert systems provide the Army with something it may not have in every unit, an expert. Since these systems are knowledge base engineering they require the input of knowledge of an individual or small group of individuals. The expert system code is written and the database compiled. No longer do soldiers have to go find an expert to assist them in the trouble shooting of their equipment.

These systems are very flexible and can be upgraded or changed, only requiring the information concerning the maintenance or repair of a particular piece or type of equipment be provided. A spin-off of the use of expert computer systems is the ability to integrate other expert systems together. This will provide even greater flexibilities in the future as expert system technologies improve both in software and hardware. Additionally the Army does not need to reinvent the wheel in many cases to develop some expert systems. Many of the operations that fall into the Army's base operations arena can utilize expert systems currently in use by many industries today. Examples of some such systems are expert systems that assist in the purification of water, systems that monitor the input of chemicals into waste treatment facilities, systems used in warehouses to assist in the purchase of new inventory and

the efficient movement of the inventory. Another area that expert systems are readily available is in the field of medicine.

Although the base operations side of the Army can use available commercial expert systems the operational and tactical side of the Army's operations are not so readily available. It is in this area that the Army must do much of the work to utilize expert systems. There are very few if any industries in the civilian community that have a need for the type of decision aids necessary for the operation of the Army. To this end the Army must develop or have developed expert systems that assist the commander in the operation of his unit.

This is not to say that there are not currently expert systems used in the civilian sector that cannot be used as part of the decision making process. There are available expert comp... systems that may be of use as a component part of the overall architecture. However, there does not currently exist a system in the civilian community or in the military that will fill this void.

The second question that must be addressed is the direction the Army is headed in the area of all other types of artificial intelligence, such as robotics, neural networks, pattern recognition, speech recognition, and natural language translation to identify only a few. As identified earlier, there are those in the artificial intelligence community who would argue that some of the

above mentioned items do not fall under artificial intelligence but as in the case of robotics, should fall under another discipline such as mechanical engineering. It is a general consensus that robotics does fall under the artificial intelligence umbrella.

Work in this area in the Army has appeared to slow down and in many cases even halted completely. Those cells currently still working on artificial intelligence projects such as pattern recognition and neural networks are only making slow progress. One area of new interest is in the combining of expert computer systems with neural networks. The basic premise of the project is to build a knowledge based system and then use it to teach the neural network. This would require human input only at the beginning of the project. This concept is new but does show promise of becoming very useful in the future.

There are those within the Army who have divided artificial intelligence into two components. The first are those projects that have low cost and small benefits. The second are those projects requiring large amounts of research, money and provide great benefit to the Army. Some say that money should be diverted from the small payoff projects to the research of those projects with greater potential payoff to the Army in the future. It is currently unclear if this type of reallocation of research money will ever take place.

The bottom line to the usefulness of artificial intelligence is still unclear. This is not to say that the potential uses of these technologies are not of potentially great value because they are. The difficulty rests in the ability of these technologies to provide useful benefit to the Army in the short term while also providing a reasonable return on the research investment costs.

In these times of dwindling budgets and manpower a third question must be addressed with regards to both expert computer systems and artificial intelligence. This question must address the Army's possible change in the role it currently plays in both technologies; one of a follower of technology. Will the Army's future role in these technologies be more affected by a reduced budget or a reduction in manpower or will it be a combination of the two limitations?

Although outwardly the question may appear to be simply answered as a combination of the two the items must be looked at independent of the other before any conclusion can be made. An example is the change or perceived change in the Army's attitude to sending soldiers to civilian institutions to receive hard science degrees. The reduction in the budget will most certainly also decrease the numbers of soldiers sent to civilian university. But in many cases the Army appears to be committed to continuing its previous levels of research and development dollars at least in the near term. If this is the case for research and development

dollars and there is a reduction of soldiers attending universities then perhaps the answer is to replace the soldiers with civilians.

There is a danger in replacing the military experts with civilian experts in the research and development of these technologies. The danger is the lack of actual experience in the operation of a military unit and the particular requirements of a commander involved in an operation. This is not to say that department of the Army civilians do not understand the functions of the Army but rather to say that an experienced soldier can provide experience to his knowledge of the technology and provide a product faster with more of the needs of the commander in mind than perhaps could be done otherwise. One case in point is the Eagle project. The officers working on the project have experience in an army field unit as well as advanced education on expert systems and the writing of the code. This allows theses officers to write the necessary code rather than have them attempt to explain the needs of a commander in the field to a computer programmer and the programmer write the code the way he thinks it should be written. With this method in place much more supervision must take place to ensure that the end result is what the commander needs. If however the officer writing the code has the experience he does not have to attempt to explain the requirements but rather writes them himself thereby

removing one step in the process and making the system better and less costly.

It is also very important that the Army have a pool of individuals educated to understand the intricacies of both technologies. This will ensure that the Army gets from industry and the various artificial intelligence cells the products it wants and not pay for something it neither wants nor needs. An additional benefit is the ability of the soldier to understand the entire architecture from a users point of view and will be better able to envision the use of these systems.

There are those that disagree on the need to have Army personnel ensure that the Army gets what it wants at a price and value consistent with the contractors promises. The principle that must guide the Army in this issue, regardless of methodology used, is for the Army to be a smart consumer when investing in either technology.

A fourth question to be analyzed is the problem with the way the Army is developing and using these technologies. There are those that believe the Army is attacking these technologies from the wrong point of view and that is from a hardware aspect. These individuals believe that most of the hardware problems can be solved through the use of commercially purchased equipment and the Army should pay the smart people to develop these technologies. This group of people believe the Army should merely exploit the civilian communities advances in both technologies.

The fifth area that exists is the "Not Invented Here" syndrome. This is not a new problem for the Army nor is it a problem that exists only in the Army. This same type of condition exists to some extent in the civilian sector as well. This attitude however can create huge impediments to the creation and production of one or both types of technologies. It can have a significant impact on the distribution of research and development funds and on various cells working collectively to solve a problem.

A sixth question that must be addressed is one of fiscal limitations. An example might be a program manager. It is certainly not to his advantage to take any risk as far as his project is concerned. His job is to bring the project in on schedule and under budget. Who cares what it is if it meets the above mentioned criteria. There is little if any flexibility available to the project manager even if he sees an opportunity to add some new technology, he must evaluate the extra millions of dollars that must be spent and the delay in time to incorporate the new technologies. This is not to say that the Army does not always try to get the biggest bang for its buck, but rather it is a reflection of a system that is perhaps not flexible enough to change even when technologies do.

The seventh question that must be answered is if there would be any future benefit to the Army if it changed its role from one of a follower of technology to one of leadership in both expert computer systems and artificial

intelligence. This question is closely linked to the need to reinvent the wheel or to continue to dove tail industry and adapt the technologies they develop to meet the future needs of the Army.

One point that is very clear is how the Army was able to defeat the Iraqi Army while suffering so few casualties. The ultimate answer is through the use of smart weapon systems and other advanced technologies to include several expert systems and other artificial intelligence applications. The issue to be evaluated, given how the last war was won, is how best to remain technologically ahead of our next foe so that we can reasonably expect the same results.

The eighth question that must not be over looked concerns the control of these various artificial intelligence cells throughout the Army. Should the control of the cells be centralized under one authority or should they remain separate autonomous elements? The question here is one of vision and intent. Although on the surface the question of vision and intent may appear simple the answer is not. The issues of control are complexed and may not be solvable in the short run.

It would seem logical that all of these separate cells would benefit from one centralized authority which could provide assistance to the cells while eliminating any possible redundancy. The possible danger in this scenario is the "Not Invented Here" syndrome. By having a

centralized control of the artificial intelligence cells the Army leadership might decrease the numbers of these cells and thereby save money and resources. By doing this the Army may also stifle initiative and eliminate the competition that currently exists among the various separate cells. An additional danger may exist if parochialism should raise its ugly head. An example might be if the signal corps were to provide the overall management of these artificial intelligence cells it would be very easy to provide more money and research to those projects that would specifically address communication issues. It would probably be the same result regardless of the branch given centralized control over these cells. This not to say that parochialism would necessarily exist but rather the possibility of its existence certainly does.

A final area that must be explored is the possibility of the Army changing its commitment to either expert computer systems or artificial intelligence in the future. This may well be the most difficult issue to evaluate. Given the current reductions in manpower expected and the Army's budget also in question, it may be pure speculation as to the Army's commitment over time to these technologies. The task may be difficult but certainly not impossible.

Certainly the past performance of the Army to want the newest forms of technology speaks well on the side that believes the Army's commitment will continue and perhaps even grow. This particular view does appear to fly in the

face of reason when the Secretary of Defense has said that he would rather eliminate weapon systems rather than personnel. However, it may be that as the procurement of fewer weapon systems continues into the forcible future, the need to provide more resources for research and development may increase as a spin-off of the reduced budget.

RECOMMENDATIONS

The role the Army should play in the evolution of expert computer systems and artificial intelligence is quite clear. The Army current role in these technologies is in mostly a follower's role and for the most part should remain unchanged into the foreseeable future.

If one examines closely the various components of the question there are many issues that are quite clear while others may not be so clear but to simply change them would be of little benefit to the Army. In the case of the direction the Army is taking with expert computer systems, the Army is doing quite well. The Army does not need to reinvent the wheel but rather should use those expert systems available in the civilian community where possible. This will provide a system that has proven reliability without the cost of research or the cost to have the program developed.

Granted there are cases where this is not a viable solution as is the case with the operational and tactical decision making process. The command and control process is

a complexed issue that requires a tremendous amount of input and support. Input must be provided by all of the staff sections and the input must be continuously updated. Once compiled it must provide various courses of action and then these courses of action must be wargamed and finally one course of action recommended above the others. There does not currently exist a software answer to this complex problem. There are however solutions to various component parts of the command and control issue and the Army must continue to explore these areas and attempt to combine whatever technologies are possible to make the system work as best it can.

The answer is not however to take a leadership role in the research and development of these technologies. A better solution from the Army's perspective is to identify the problem to industry, one of the national laboratories, or even to civilian university and attempt to guide the research to solve these types of problems. The Army should provide assistance to Ph.D. students who are working in areas of interest to the Army. This appears to be an area that has received more attention recently but could certainly be exploited even more.

Perhaps a danger in this is the short term the student would work on a project. Given the time constraints, the Army would have to monitor the student's progress and ensure projects given the students can be completed and not left unfinished.

In considering the direction the Army is heading with regards to artificial intelligence the answer is equally clear. Be a smart consumer and utilize the existing technologies that presently exist. While neural networks and pattern recognition types of artificial intelligence offer great promise for future use the status of development does not recommend the expenditures of great deals of money. This is not to say that the Army should not play a significant role because it should. The Army must provide guidance to assist in the development of defense projects that allow the Army to keep its technological lead over other nations around the world. It is this requirement to keep the technological lead that is the driving force behind this type of research and it must continue. However, it is not necessary that we develop the technology but should instead exploit any and all possible uses of it into our command and control systems and weapons platforms.

An additional influence on the Army's role as a follower of technology rests with the decreasing budget and manpower in near term. An obvious by product of a reduced budget and manpower is the brain drain that will occur in the Army. The trade off problem that exists is one in which the Army sends a soldier to get a Ph.D. in computer science for example. The soldier does two or three years and then must go back to a troop assignment to stay competitive with his peers. After several years with troops the individual would be hard pressed to be of any use in a research and

development assignment due to the quickly changing developments in both expert systems and artificial intelligence. The key to the Army's success here is to continue to send soldiers to receive their advanced degrees and to then utilize them in that capacity for longer periods of time without making them non-competitive for promotions.

Perhaps the greatest problem with the way in which the Army is developing expert systems and artificial intelligence is the Army's search for hardware solutions to software problems. This is not to say that better hardware cannot be produced, but rather the greatest impediment to progress is the development of the required code. Of secondary concern is the Army's ability to be a good consumer and not buy a system because it had all kinds of bells and whistles. This is easily done especially when dealing in the area of expert computer systems and artificial intelligence. An example might be the Army buying an expert system when a relational database would suffice.

When one considers the future benefit to the Army, if it were to change its role from one that follows the evolution of technology to one of a leadership role, it is clear that the Army would not benefit. Albeit important to guide the various types of technological development, the Army should use its personnel resources to ensure that the products received do what they claim they will do and also

can be updated without throwing out the entire system and having to start the process over.

Perhaps the most delicate of the issues is one over the control of the various artificial intelligence cells throughout the Army. Although on the surface it may appear that these separate cells should be under centralized control the best solution is to allow the various centers to have their autonomy. By allowing these separate cells to be autonomous there exists a level of competition among them which in turn will hopefully make them work harder to receive more money to do more research. The Army is the all around winner in this category. Another advantage to having semi-autonomous cells is the ability to allow individual initiative. It is perhaps this initiative that is most important to the development of new systems. This does not mean that the Army should not have a strategic goal and intent so that these centers could have directions. The Army must provide this overall guidance to these cells so they understand the overall importance of their work as a whole rather than as a small component. The serious danger in not providing this vision and intent is clear in the following example.

The artificial intelligence cells are all working on their component part to the command and control system and one day they are all successful. Outwardly one would think this is wonderful and their problems are over. Quite the contrary, their problems have just begun. The problem that

would arise from all of the success are modules or component parts that would not have compatible protocols that allow for the interconnectivity of the various components. This leads to the "Black Box" solutions to compatibility problems. The black box approach was an approach to find a way for two separate systems to communicate with each other. True, it solved the problem in the short run but hampered the Army in the long term. As upgrades became available the black box would no longer work and the system would have to be scratched and started again. If the Army provides these cells with the appropriate level of vision and intent these "Black Box" problems need not occur.

One such solution is to ensure that all cells adhere to the common hardware-software approach. This provides for common operating systems and will also allow individual modules to be replaced as upgrades become available without having to scrap the system.

In considering the possibilities of the Army changing commitment in the future concerning both of these technologies, one must consider change as being inevitable given the changing world environment. This study has painted a picture in time and does not show the totality of the Army's effort. Rather it shows a cross section of efforts across a wide spectrum of the Army. What will not change is the Army's commitment to keep a technological advantage over other countries in the world. In order to do that with reduced manpower and budgets the Army must remain

a smart consumer. Additionally our systems must be compatible to allow for the changes in expert computer systems and other forms of artificial intelligence that are just over the next horizon.

In summary the Army will play a significant role in the future evolution of both expert computer systems and artificial intelligence. Albeit it from the role of a follower of technology the Army will guide the bright minds in our research and development departments to continue to exploit all possible solutions to the complex problems of weapon systems and the command and control systems of tomorrow.

APPENDIX A

USAMRIID PROJECT SUMMARY

PROJECT TITLE: Disease Prediction by Remote Sensing of Environment

NARRATIVE DESCRIPTION:

Outbreaks of Rift Valley Fever (RVF) disease in domestic animals in sub-Saharan Africa are clearly correlated with widespread and heavy rainfall. It is thought that this rainfall can flood mosquito breeding habitats, known in Kenya as "dambos." The goal of the project is to use remotely sensed images to predict where these breeding grounds are. This information will be used to help military strategist determine the safest location to establish military camps and whether these soldiers should be vaccinated for RVF.

Currently, LANDSAT Thermatic Mapper (TM) and SPOT images have been used in this study. Statistical analysis is being used to refine these techniques. Ground truth has increased the accuracy of supervised classification of dambos. Radar image technology is in place to augment this study.

HARDWARE/SOFTWARE/MEMORY REQUIREMENTS:

Symbolics 3600 Workstation,Pixar Image Computer, Sharp Color Scanner. Genera 7.2 O.S., Scope Image Processing Software.

DEVELOPER/SPONSOR:

U.S. Army Medical Research Institute of Infectious Diseases (USAMRIID)
Fort Detrick
Frederick, MD 21701-5011
Dale R. Angleberger and MAJ Ken Linthicum
(301) 663-7514

STATUS:

Currently USAMRIID is in the process of acquiring an imaging system that will allow the Institute to employ GIS and GPS technology along with state-of-the-art image processing software.

INPUT DATA:

L, X, and C Band radar; LANSAT TM and SPOT images; Digital images of scanned hard copy maps and photographs

OUTPUT DATA:

Images that have been run through the classifier containing identified dambos

RELEASE LIMITATION: TBD

USAMRIID PROJECT SUMMARY

PROJECT TITLE: Exposure

NARRATIVE DESCRIPTION:

Determine medical response to accidental infectious agent exposure in a research lab. Exposure contains information on infectious agents, diagnostic procedures, and potential treatments to assist physicians in their response to an agent exposure within the Institute.

HARDWARE/SOFTWARE/MEMORY REQUIREMENTS:

IBM PC or compatible
LEVEL5 Expert System shell
512K

DEVELOPER/SPONSOR:

U.S. Army Medical Research Institute of Infectious Diseases (USAMRIID)
Fort Detrick
Frederick, MD 21701-5011
Tim Cannon and MAJ Hack
(301) 663-7514

STATUS:

Currently being refined

INPUT DATA:

Type of accidental exposure and agent involved

OUTPUT DATA:

Disposition and treatment

RELEASE LIMITATION: TBD

USAAIC PROJECT SUMMARY

PROJECT TITLE: SABRE - Single Army Battlefield Requirements Evaluator

NARRATIVE DESCRIPTION:

SABRE is an integrated executive support system that provides a window for exploring the current and projected structure and condition of the US Army. It consists of four component modules: FORCEMAPS, Fast Interactive Status Projections (FISP), SMART, and Force Closure. In FORCEMAPS, a user can interactively specify a context for viewing a force in terms of theater, operation plan, year, day of the war, or other criteria. The requested force structure is then graphically displayed using a tree diagram showing command relationships and a variety of user-selectable projected readiness condition indicators. Information displayed can be aggregated and displayed for different levels of detail. A variety of reports are also available. FISP provides a comparative display of projected unit readiness based on the programmed acquisition of new and existing systems. FISP also supports multiple ratings projection databases, allowing comparison of proposed reporting policies. SMART is a collection of graphically enhanced special reports that allow a user to compare forces or units and explore the projected modernization of units. Force Closure graphically depicts the flow of units into a theater as specified in applicable operation plans along with their projected readiness.

TECHNICAL APPROACH:

The tree structure displayed in SABRE is a representation of an object oriented database, with links to other databases, with links to other databases containing information from a variety of Army information systems. The display serves as the primary interface, using high resolution, mouse sensitive graphics for the analyst to select the view of the interaction between the multiple databases. The tree has proven to be an excellent interface model for force structure analysis, and is adaptable to other data integration problems in which objects contain other objects.

KEYWORDS:

Decision Aids, Knowledge representation, Management Systems

DEVELOPMENT HW/SW/OPERATING SYSTEM/MEMORY RQMTS:

Symbolics 3600 w/color system, LISP, Genera 7.2 O.S, 6MW memory, 1 Gbyte hard disk

DELIVERY HARDWARE/SOFWARE/OPERATING SYSTEM/MEMORY RQMTS:

Symbolics 3600 w/color system, LISP, Genera 7.2 OS, 6MW memory, 1 Gbyte hard disk

DEVELOPER:

US Army AI Center.

SPONSOR:

Program, Analysis and Evaluation Directorate, Office of the Chief of Staff, Army.

STATUS:

Version 2.0 released SEP 1991.

INPUT DATA:

Force Accounting System (FAS) Force File (PROFA) Major Operation Plan (OPLAN) Time Phased Force Deployment Listings (TPFDL) Total Army Equipment Distribution Program (TAEDP)

OUTPUT DATA:

Displays unit organization, projected war-fighting capability, either individual or aggregate, and other views of the structure and characteristics of the force being analyzed.

SECURITY CLASSIFICATION:

SECRET due to data used. An UNCLASSIFIED database based on a Notional Corpsis available.

RELEASE LIMITATIONS:

Restricted.

US ARMY AI CENTER, ATTN: CSDS-AI(CPTWILMER), PENTAGON, AV224-6900

USAAIC PROJECT SUMMARY

PROJECT TITLE: PCIA - Program Change Impact Analysis

NARRATIVE DESCRIPTION:

The Army Tactical Command and Control System (ATTCCS) is a major procurement designed to support C3 activities into the next century. Full fielding involves integration of five command systems and three communications systems on common hardware and software in common shelters. All system development cycles are interwoven and numerous interdependencies exist within and between systems. Minor funding or schedule changes often propagate through the interdependencies, resulting in gross inefficiencies. Major management efforts are required to repair budgets, schedules, and contracts before the inefficiencies can become institutionalized.

PCIA allows the SI to make changes in funding or scheduling and immediately view the effects in the budgets and fielding of the system. Multiple systems can be compared, and graphs across time can be produced.

TECHNICAL APPROACH:

PCIA incorporates a model of the SI's decision making process in a group of objects. Costing functions and inflation rates accurately reflect the actual figures used.

KEYWORDS:

Decision Aids, Object Oriented System, Finance Systems

DEVELOPMENT HW/SW/OPERATING SYSTEM/MEMORY RQMTS:

Macintosh II microcomputer with a Lisp coprocessor (TI MicroExplorer), MicroExplorer development environment, 8MB RAM, 330 MB Hard Disk.

DELIVERY HARDWARE/SOFTWARE/OPERATING SYSTEM/MEMORY RQMTS:

Macintosh II microcomputer with a Lisp coprocessor (TI MicroExplorer), MicroExplorer run-time environment, 4MB RAM, 100 MB Hard Disk.

DEVELOPER:

US Army AI Center.

SPONSOR:

ODCSOPS,ODISC4

STATUS:

MicroExplorer version completed, currently being ported to MS-DOS platform using C++ and PC-CLOE.

INPUT DATA:

Force Accounting System (FAS) Force File (PROFA), Total Army Equipment Distribution Program (TAEDP), Program Specific Data from PM and SI.

OUTPUT DATA:

System budgets, fielding schedules, line-graphs, system comparison info.

EXPECTED RETURN ON INVESTMENT:

SECURITY CLASSIFICATION:

PCIA itself is not classified, however, the data it operates may be classified SECRET depending on the system being used.

RELEASE LIMITATIONS:

Restricted to Army personnel for classified systems, unrestricted for unclassified systems.

US ARMY AI CENTER, ATTN:CSDS-AI(ROBERT POWELL),PENTAGON,AV 224-6900

USAFISA PROJECT SUMMARY

PROJECT TITLE: TAANK-Total Army Analysis Knowledgebase

NARRATIVE DESCRIPTION:

TAANK is an intelligent decision support system that will function as an interface to analytical tools as well as to an integrated departmental database, and associated knowledgebase. TAANK consists of five component modules: a Data System module, and modules for Organization Integrators, Force Integrators, System Integrators, and Document Integrators. The Data System module will access all of the relevant databases and provide a means to correlate information from one database to another. The remaining modules will provide a user oriented graphical interface that will provide access to the required data, as well as menu options that will invoke analytical processes as well as inferencing routines.

TECHNICAL APPROACH:

The TAANK software design combines database technology with object oriented programming. The ORACLE relational database management system provides an abstract database interface that will link to DB2 files located on an IBM 3090 mainframe computer and provide distributed database processing. An object system built in common LISP will provide the user interface as well as the objects needed for the inferencing and analysis components.

KEYWORDS:

Decision Aids, Knowledge Representation, Object Oriented System.

DEVELOPMENT HW/SW/OPERATING SYSTEM/MEMORY RQMTS:

MacIntosh II with Ivory model II board, 2MW memory, 650 Mbytes, LISP, Genera 8.0

DELIVERY HW/SW/OPERATING SYSTEM/MEMORY RQMTS:

MacIntosh II with Ivory model II board, 2MW memory, 650 Mbytes, LISP, Genera 8.0 SUN SPARC 1, LUCID LISP,UNIX 4.0

DEVELOPER:

US Army Force Integration Support Agency.

SPONSOR:

Office of the Deputy Chief of Staffs for Operations and Plans.

STATUS:

Data System and FI System to be released in August 1991; DI System in December 1991, OI and SI Systems TBD.

INPUT DATA:

Force Accounting System (FAS) Force File (PROFA), Table of Organization and Equipment (TOE), Total Army Equipment Distribution Plan (TAEDP), The Army Authorization Documents System (TAADS), other TBD.

OUTPUT DATA:

Command and Force Package tree diagram from PROFA; Paragraph tree diagram from TAADS, TOE; Sections II, III from TOE, TAADS; Standard force structure reports from PROFA; Readiness reports from TAEDP; User defined management reports as needed.

EXPECTED RETURN OF INVESTMENT:

SECURITY CLASSIFICATION:

SECRET due to data used.

RELEASE LIMITATIONS:

Restricted.

USAFISA,ATTN: MOFI-SD-A,PENTAGON RM 3C457, WASHINGTON DC 20310, AV 223-5742.

USAMRIID PROJECT SUMMARY

PROJECT TITLE: Safety Expert System

NARRATIVE DESCRIPTION:

There is a great deal of safety information (guidelines, regulations, instructional materials, etc.) that impacts in USAMRIID researchers and other personnel. This expert system is intended to disseminate this information in an organized way.

HARDWARE/SOFTWARE/MEMORY REQUIREMENTS:

IBM PC or compatible
LEVEL5 Expert System shell
512K

DEVELOPER/SPONSOR:

U.S. Army Medical Research Institute of Infectious Diseases (USAMRIID)
Fort Detrick
Frederick, MD 21701-5011
Tim Cannon
(301) 663-7514

STATUS:

Currently being used
Adding more information

INPUT DATA:

User's safety questions

OUTPUT DATA:

(Parts of) regulations, guidelines, etc that answer questions

RELEASE LIMITATION:

TBD

USAMRIID PROJECT SUMMARY

PROJECT TITLE: Biological Defense Expert System

NARRATIVE DESCRIPTION:

As part of the biological defense research program, USAMRIID is developing an expert system based on the knowledge of biological warfare experts. The completed expert system will aid users in assessing biological warfare threat, attack, diagnosis, and response to potential threat agents.

HARDWARE/SOFTWARE/MEMORY REQUIREMENTS:

IBM PC or compatible
LEVEL5 Expert System shell
512K

DEVELOPER/SPONSOR:

U.S. Army Medical Research Institute of Infectious Diseases (USAMRIID)
Fort Detrick
Frederick, MD 21701-5011
Tim Cannon and Bill Patrick
(301) 663-7514

STATUS:

Completed prototype - making refinements

INPUT DATA:

Information gathered from terrorist or attack

OUTPUT DATA:

Level of threat and potential response

RELEASE LIMITATION:

TBD

USAMRIID PROJECT SUMMARY

PROJECT TITLE: Immunization System Expert System

NARRATIVE DESCRIPTION:

The USAMRIID Special Immunization System is a large database that contains immunization histories of Institute researchers and other personnel in the Department of Defense that use USAMRIID's vaccines. The database also contains resulting antibody levels and reactions to the vaccines. This expert system will contain information about the data in the database and knowledge gained from research done on the database.

HARDWARE/SOFTWARE/MEMORY REQUIREMENTS:

IBM PC or compatible
LEVEL5 Expert System shell
512K

DEVELOPER/SPONSOR:

U.S. Army Medical Research Institute of Infectious Diseases (USAMRIID)
Fort Detrick
Frederick, MD 21701-5011
Tim Cannon and Dwayne Oland
(301) 66307514

STATUS:

Under development

INPUT DATA:

User selected information

OUTPUT DATA:

Desired information on system

RELEASE LIMITATION:

TBD

USAMRIID PROJECT SUMMARY

PROJECT TITLE: Schedule

NARRATIVE DESCRIPTION:

This AI program schedules immunizations and tests for all at-risk personnel engaged in microbiological research at USAMRIID. The program determines when personnel should report for primary vaccination, booster, or testing for antibody titers for each disease. The AI program minimizes a worker's visits to the nurse while maintaining appropriate immunization and test schedules for multiple microorganisms.

HARDWARE/SOFTWARE/MEMORY REQUIREMENTS:

AMDAHL mainframe
NATURAL and ADABAS software

DEVELOPER/SPONSOR:

U.S. Army Medical Research Institute of Infectious Diseases (USAMRIID)
Fort Detrick
Frederick, MD 21701-5011
Tim Cannon
(301) 663-7514

STATUS:

Completed - currently used within USAMRIID

INPUT DATA:

Special immunizations database

OUTPUT DATA:

Shot and bleed schedule

RELEASE LIMITATION:

TBD

PERSCOM PROJECT SUMMARY

PROJECT TITLE: Strength Analysis and Reporting System (SARS)

NARRATIVE DESCRIPTION:

The purpose of this system is to apply substitution rules to crosslevel officer assets within an Army installation by MACOM, thus providing info used to validate or deny requisitions in the next requisition cycle. A new requisition cycle begins every month. A cycle focuses on either CONUS or OCONUS requisitions, alternating each month. An officer strength data file is derived from information on the Officer Master File (OMF) and requisition database. This strength file contains six month projection info for CONUS and ten month projection info for OCONUS installations. The file is downloaded from an IBM mainframe to a Sybolics Lisp Machine via SNA. Substitution rules (i.e. upward grade, downward grad, compatible specialties, and compatible specialties for specific TRADOC schools) are applied within each installation/MACOM account.

The system originally handled just OPMD managed assets in grades LT thru LTC on CONUS cycles. The system supports both CONUS and OCONUS cycles and warrant commissioned grades thru COL.

HARDWARE/SOFTWARE:

Symbolics 3650 / Genera 7.2

DEVELOPER/SPONSOR:

PERSCOM OPMD KEG (TAPC-OPD-P) / Officer Distribution Division (TAPC-OPD-A) both of PERSCOM, 200 Stovall Street, Alexandria, VA 22332-0314

STATUS: Production / Enhancement

INPUT DATA: Strength projection report, flat file produced on mainframe

RELEASE LIMITATION: None

PERSCOM PROJECT SUMMARY

PROJECT TITLE: Desert Shield/Storm Requisition Support

NARRATIVE DESCRIPTION:

Support decisions about the capability of specified strength management accounts to meet anticipated or real Desert Shield/Storm (DS) requisitions. Utilizes a modified version of the SARS model.

HARDWARE/SOFTWARE:

Symbolics 3650 / Genera 7.2

DEVELOPER/SPONSOR:

PERSCOM OMPD KEG (TAPC-OPD-P) / Officer Distribution Division (TAPC-OPD) both of PERSCOM, 200 Stovall Street, Alexandria, VA 22332-0314

STATUS:

Production

INPUT DATA:

ODAS strength flat file, and requisition demand file

RELEASE LIMITATION:

None

PERSCOM PROJECT SUMMARY

PROJECT TITLE: Branch Detail Distribution System

NARRATIVE DESCRIPTION:

The purpose of this system is to determine a good distribution for branch detail lieutenants under programs of varying detail periods, branch participation, and acceptable distribution characteristics. Lieutenant positions accounted for by branch (those participating in the detail program) and station (geographical location within which a move incurs no cost). Detail numbers by branch are input which in turn drive an algorithm that searches for a best combination of detail branch location and career branch location. (Heuristic search methods were implemented but are not now used.)

HARDWARE/SOFTWARE:

Symbolics 3650 / Genera 7.2

DEVELOPER/SPONSOR:

PERSCOM OMPD KEG (TAPC-OPD-P) / Officer Distribution Division (TAPC-OPD) both of PERSCOM, 200 Stovall Street, Alexandria, VA 22332-0314

STATUS:

Prototype complete. Being enhanced into a production system that will recommend a distribution plan for an entire year's cohort of accessed lieutenants.

INPUT DATA:

PMAD extract, OMF extract, and detail populations sizes.

RELEASE LIMITATION:

None

PERSCOM PROJECT SUMMARY

PROJECT TITLE: Continuation Rates

NARRATIVE DESCRIPTION:

The purpose of this system is to provide Army wide, 30 year, continuation rates for the Officer population by CMF, Sex, Ethnic Group, READCAT, Component, and Source of Commission. The system also provides statistical data for use in inventory projection modeling.

HARDWARE/SOFTWARE:

Symbolics 3650 / Genera 7.2

DEVELOPER/SPONSOR:

PERSCOM OMPD KEG (TAPC-OPD-P) / Officer Distribution Division (TAPC-OPD) both of PERSCOM, 200 Stovall Street, Alexandria, VA 22332-0314

STATUS:

Production

INPUT DATA:

Year End OMF extract

RELEASE LIMITATION:

None

PERSCOM PROJECT SUMMARY

PROJECT TITLE: Accession Planning

NARRATIVE DESCRIPTION:

The purpose of this system is to provide recommendations for the distribution of accessions for a given year. System runs off the Continuation Rates Model, and utilizes the output of that system. It also takes into account Branch Details, and grade substitutions.

HARDWARE/SOFTWARE:

Symbolics 3650 / Genera 7.2

DEVELOPER/SPONSOR:

PERSCOM OMPD KEG (TAPC-OPD-P) / Officer Distribution Division (TAPC-OPD) both of PERSCOM, 200 Stovall Street, Alexandria, VA 22332-0314

STATUS:

Production

INPUT DATA:

Army continuation rates, branch authorization data

RELEASE LIMITATION:

None

PERSCOM PROJECT SUMMARY

PROJECT TITLE: Senior Service College Slating

NARRATIVE DESCRIPTION:

The purpose of this project is to assist the Senior Service College (SSC) proponent and assignment officers in determining the availability and best match of officers selected for SSC, with the next cycle of SSC schools/fellowships. Given a database of officers selected for SSC, the slating system employs a knowledge base of both backward and forward chaining rules for determining officer availability, as well as desired school/fellowship entrance criteria, and provides a recommended list of candidates for each.

HARDWARE/SOFTWARE:

Macintosh IIfx/NExpert Object

DEVELOPER/SPONSOR:

PERSCOM OMPD KEG (TAPC-OPD-P) / OPMD Career Managers both of PERSCOM, 200 Stovall Street, Alexandria, VA 22332-0314

STATUS:

Knowledge Gathering/Prototype

INPUT DATA:

School requirements, officer preferences, selected officer OMF data, projected requirements.

RELEASE LIMITATION:

None

PERSCOM PROJECT SUMMARY

PROJECT TITLE: Command and Staff College Slating

NARRATIVE DESCRIPTION:

The purpose of this project is to assist the Command and Staff College (CSC) proponent and assignment officers in determining the availability and best match of officers selected for CSC with the next cycle of CSC courses. Given a database of officers awaiting attendance to CSC, the slating system employs a knowledge base of both backward and forward chaining rules for determining officer availability as well as course entrance criteria and provides an ordered list of candidates for each course being filled, to include courses at sister service schools and the School of the Americas.

HARDWARE/SOFTWARE:

Zenith 248 / Turbo Pscal 3.01

DEVELOPER/SPONSOR:

PERSCOM OMPD KEG (TAPC-OPD-P) / OPMD Career Managers both of PERSCOM, 200 Stovall Street, Alexandria, VA 22332-0314

STATUS:

Producton/Enhancement

INPUT DATA:

A file with pertinent info off the OMF and provided by assignment officers on officers selected for CSC.

RELEASE LIMITATIONS:

None

USAAIC PROJECT SUMMARY

PROJECT TITLE: BLACKSMITH

NARRATIVE DESCRIPTION: Blacksmith was conceived during Desert Storm at the direction of the Vice Chief of Staff, Army to provide a system which will support CSA/VCSA decision making. It will be used initially to display and ultimately to predict the impact of policy decisions, in the context of actual or conjectural external scenarios and resource constraints, on the size, readiness, and capability of the Army over time from the current year through the last year of the POM. It will provide a holistic view of the Army, integrated across the functional areas (operations, personnel, logistics, facility management, RDA, program & budget etc.), in order to focus the CSA/VCSA on the actions and policies that may cause divergence from the desired end-state. It will assist in determining the "best" set of actions and decisions from an integrated Army perspective instead of the sum of the "best" from a functional perspective. It will also explain the causes and tradeoffs in decisions that are predicted to cause detrimental impacts i readiness and capability, and provide policy rational to external groups (i.e., Congress, DOD, etc.), ARSTAF, and MACOMs.

TECHNICAL APPROACH: A distributed object-oriented approach combined with other artificial intelligence techniques to model the behavior of key Army "objects" - units, personnel, supplies, installations, and dollars. The model simulates "How the Army Runs" by adding behavioral characteristics to its objects. The model depicts the interaction of these objects overtime and allow its user to see the impact of policy / scenarios through the setting of user controllable input "dials" and "switches." The output will be displayed on a highly visual, geographic display.

KEYWORDS: Decision Aids, Knowledge Representation, Object Oriented System.

DEVELOPMENT HW/SW/OPERATING SYSTEM/MEMORY RQMTS:
SparcStation s/Color Monitor, ProKappa 2.0 & ORACLE(s/SQL*Net) & GCC & X-Windows (w/Motif widget set), Sun OS 4.1.1, 28M memory, 110M disk space + 70M swap space.

DELIVERY HARDWARE/SOFTWARE/OPERATIONG SYSTEM/MEMORY RQMTS:
Network of high performance UNIX workstations w/Color Monitors, X-Windows, POSIX compliant OS, 1G Disk space + 200M swap space per workstation.

DEVELOPER: US Army AI Center.

SPONSOR: Vice Chief of Staff, Army

STATUS: Initial Development Phase.

INPUT DATA: Force Accounting System (FAS) Force File (PROFA) and extracts from the Facilities databases. Several more input sources will be required as the system expands.

OUTPUT DATA: Currently, it displays a resizable map showing the locations of 32 U.S. installations. Dialog boxes show various information such as which units are on an installation. Buttons allow certain actions to occur such as closing an installation. Graphs are used to show changes over time.

SECURITY CLASSIFICATION: SECRET due to data used.

RELEASE LIMITATIONS: Restricted.

US ARMY AI CENTER, ATTN: CSDS-AI(MAJ GUSSE), PENTAGON,

AV 224-6900

USAAIC PROJECT SUMMARY

PROJECT TITLE: Document Organizer

NARRATIVE DESCRIPTION: The Document Organizer is a computer program that allows a user to graphically view, modify, and analyze documents that are generated by the Army Authorization Document System (TAADS). TAADS documents reflect personnel and equipment requirements and authorizations for all Army organizations. The system is designed to display and query TDA, MTOE, and TOE "flat" files; however, TOE documents have not yet been fully implemented and tested.

HARDWARE/SOFTWARE/MEMORY REQUIREMENTS: Object-oriented system that relies extensively on Symbolics' New Flavors. Written in LISP, the system runs on either a Symbolics or MacIvory (MacII with an Ivory Processor board) computer. The program source and object files require about 6500 fep blocks (8 megabytes) of disk space for paging files. Data file space varies; the Army's entire TDA uncompressed flat file structure is about 133megabytes; largest MACOM is 18 megabytes. MTOE structure is around 275 megabytes.

DEVELOPER/SPONSOR: US Army AI Center. It is currently being used by various Pentagon agencies involved in the force alignment and reorganization process.

STATUS: Current and future work on the Document Organizer include detailed testing of the system and porting to UNIX-based and DOS-based platforms. Building MTOE authorization documents from TOE, BOIP, and ICP data input is also being studied.

INPUT DATA: TAADS flat files.

SECURITY CLASSIFICATION: Unclassified (Data is FOUO).

RELEASE LIMITATION: US Government Agencies.

POINT OF CONTACT: CPT Mike Eposito, US Army AI Center, Pentagon, Room 1D659, AV 227-6577, Com (703) 697-6577.

USAAIC PROJECT SUMMARY

PROJECT TITLE: AI Porting Tool

NARRATIVE DESCRIPTION: The purpose of this effort is to develop the capability to transfer AI systems developed under the Symbolics LISP machine Genera™ environment for delivery on a wide range of general purpose hardware systems that use the UNIX operating system. This will allow the Army Artificial Intelligence Center (and other Army agencies) to continue t develop and maintain AI applications in the developmentally rich LISP machine environment and yet field the systems on high performance generic hardware more widely available throughout the Army. The porting system will also support persistent storage of objects on an SQL compliant DBMS, logical pathname, system definitions, patches, and contain a hypertext browser to provide access to on-line help and system documentation developed under Concordia™.

KEYWORDS:

DEVELOPMENT HARDWARE/SOFTWARE/MEMORY REQUIREMENTS: Symbolics 3600 w/2 MW memory, General OS.

DELIVERY HARDWARE/SOFTWARE/MEMORY REQUIREMENTS: Unix workstation with Common LISP, XWindows and an SQL compliant DBMS.

DEVELOPER/SPONSOR: Developed by the US Army AI Center, POC: MAJ Patrick Lynch, DSN 227-7250, COMM (703) 697-7250.

STATUS: Under development, initial operating capability AUG 91 for Sun SPARC & DecStation 3100™, followed by IBM RS/6000.

INPUT DATA: Source code, system definition files.

OUTPUT DATA: Target delivery system executables.

SECURITY CLASSIFICATION: Unclassified

RELEASE LIMITATION: NONE

USAAIC PROJECT SUMMARY

PROJECT TITLE: AACES - Alternatives Analyzer, Comparer, Editor, & Sourcer

NARRATIVE DESCRIPTION: AACES is an automated tool for:

a. Sourcing (choosing the "best" units to fill) a force package or alternative force.
b. Analyzing the sourcing process to determine which types could not be sourced and why.
c. Comparing the "requirement" (base force) with the "goodness" of the solution.
d. Explaining the why -- Why units are not available? What other units are available?

Additionally, AACES includes a graphic editor (called Force Maker) to assist with constructing alternative forces/force packages. The editor allows a user to rapidly extract subforces or selected units form real forces, to create notional forces, or combine notional units and real units into a single force (alternative force). Then, for each unit (or notional unit) in the alternative force, the AACES Sourcer can identify real units "like" it and pick the "best" of those that match to replace it, producing a "sourced" alternative force. The user defines matching criteria ("like"units) and criteria for "best" unit through a series of "buttons" and "dials". Lastly, AACES provides an explanation facility to point out units not sourced and to what options criteria you could change to source them.

AACES is a module of the SABRE System (see AI Project Summary for SABRE). Using with other modules of SABRE, the impact of a given alternative force (produced with AACES) on various sustainment factors can be examined.

The system supports elements of the Program Analysis and Evaluation Directorate and other elements of the Army Staff. It has also been installed at Forces Command (J-5) (Fort McPherson, GA).

DEVELOPMENT HARDWARE/SOFTWARE/OPERATING SYSTEM/MEMORY REQUIREMENTS: AACES runs "ontop of" SABRE and requires 20 Megabytes of additional diskspace. SABRE itself requires: Symbolics 36xx w/6 MW memory, color system, & 1 Gbyte hard disk running Genera 8.02 OS.

DELIVERY HARDWARE/SOFTWARE/OPERATING SYSTEM/MEMORY REQUIREMENTS: Symbolics 36xx w/6 MW memory, color system, & 1 Gbyte hard disk running Genera 8.02 OS; MacIvory model 2 or 3, with 6 MW memory, Radius color monitor, 600 Megabytes external hard disk.

DEVELOPER/SPONSOR: Developed by the US Army AI Center for the Program, Analysis and Evaluation Directorate, Office of the Chief of Staff of the Army.

STATUS: User Test Release 1.0 (Version 11.244) is in use at FORSCOM.

INPUT DATA: (major systems) Uses data loaded in SABRE (no additional data required).

OUTPUT DATA: Described above in NARRATIVE DESCRIPTION.

EXPECTED RETURN ON INVESTMENT:

SECURITY CLASSIFICATION: SECRET due to SABRE data used. An UNCLASSIFIED database based on a Notional Corps is available for SABRE.

RELEASE LIMITATIONS: Restricted.

US ARMY AI CENTER, ATTN: CSDS-AI (MAJ LYNCH), PENTAGON, AV 224-6900

USAAIC PROJECT SUMMARY

PROJECT TITLE: Architecture Information Model

NARRATIVE DESCRIPTION: Prototype tool to support the DISC4 Architecture branch to develop, analyze and maintain the Army's Capstone Architectural Building blocks, and to relate the Architectural building Blocks of other Army organizations to the Army's Capstone Architectural Building blocks. The tool is expected to support the evaluation of the IMP initiatives, and analysis of architectural issues by the Architectural Control committee. Additionally the tool is expected to support the HQDA architecture efforts, HQDA information budgets efforts, and provide configuration management to the DIM.

DEVELOPMENT/HARDWARE/SOFTWARE/OPERATING SYSTEM/MEMORY REQUIREMENTS: MacIvory model 2, 16mb Nubus memory, Genera 8.02 OS, AIMSAT 17.46, IMP-ANALYZER 14.1

DEVELOPER/SPONSOR: Developed by the US Army AI Center of ODISC4, and ODAIM

STATUS: Prototype used by the DIM to update the HQDA information architectures; currently no more development is anticipated until the panic from the next round of budget cuts hits the HQ.

INPUT DATA: HQDA Information Model, Tactical & Strategic Information Model, Organizational Informational Models (ODCSOPS, ODCSPER, etc.), Information requirements input for new requirements, and Information life cycle data for existing systems

OUTPUT DATA: Hardcopy of the information plans, and graphs of elements of the plans, and saved files on the file system.

EXPECTED RETURN ON INVESTMENT:

SECURITY CLASSIFICATION: Unclassified

RELEASE LIMITATION: NONE

APPENDIX B

INTERVIEWS

During the course of the research for this thesis interviews were conducted with four subject matter experts. These interviews were done both in person and telephonically to provide additional background on the various projects ongoing in the Army today. In addition to the background each interviewee was asked a series of nine questions that allowed them to provide opinions and facts concerning the future role the Army should play in the evolution of expert computer systems and artificial intelligence.

The following is a synopsis of the interviews with each of the four subject matter experts.

COLONEL ARCHIE ANDREWS
UNITED STATES ARMY COMPUTER SCIENCE SCHOOL

Colonel Andrews is the Director of the United States Army Computer Science School located at Fort Gordon, Georgia. This interview was conducted on 23 January, 1992 and was done telephonically. The primary focus of this interview was to receive the background information concerning the operation of the artificial intelligence cell at the computer science school and to receive Colonel Andrews' insight into the future direction the Army may take

concerning expert computer systems and artificial intelligence systems.

Colonel Andrews stated that the Army is working very hard on the education of individuals in expert computer system technologies. He also believes that there is a definite use for expert systems across the entire spectrum of the Army. He does believe that one major issue that must be addressed is the Army's lack of an overall strategy for these technologies.

Colonel Andrews addressed the future direction the other forms of artificial intelligence by first stating that the Army needs to begin to separate the hardware and software components. He believes the Army has a good handle on the various hardware aspects but the Army must change its focus to address the software issue. He says the Army is not alone in this area but that industry must do the same thing.

When asked if the Army should play a leadership role in expert computer systems and artificial intelligence or whether the Army's role should be one of a follower of technology, Colonel Andrews said that the Army should exploit all possible systems that are available. He pointed to many instances of the civilian community currently using expert systems that could be used by the Army with little if any changes. In the other areas where there are no systems currently available to assist the Army then the Army must provide some leadership.

He also believes that declining budget and reduce manpower will have an impact on these technologies but, he also stressed the Army's continuing need for these technologies.

Colonel Andrews stated that the future for expert computer systems and artificial intelligence in the Army is very bright and important. Although he thought it might slow down somewhat during the declining budget period, the need for these technologies have proven themselves to be important.

ANNETTEE RATZENBERGER

CHIEF OF EAGLE MODEL DEVELOPMENT DIVISION

Annettee Ratzenberger is the Chief of Eagle Model Development division, TRADOC Analysis Command, Fort Leavenworth, Kansas. This interview was conducted on 24 January, 1992 and was done in person. The primary focus of this interview was to receive background information concerning the operation of the artificial intelligence cell at the at the Eagle project. Additionally Ms. Ratzenberger provided insight into the future direction the Army may take concerning expert computer systems and artificial intelligence systems as related to the Eagle project and the Army as a whole.

Ms. Ratzenberger does not believe the Army will be doing much pure research in the future. She believes that the Army is being successful by utilizing those technologies

that currently exist and changing them to fit the needs of the Army. The Eagle project is one example of a success story of the Army finding several different types of technologies available and combining to make a new by product that fits a need the Army has. She also believes that any new system developed must have be capable of integrating new technologies as they become available. One such examples she sites is in the area of neural networks and a new technology that would allow a knowledge based system to teach a neural network. This would eliminate the need for human involvement past the point of engineering the expert computer system.

One of the primary points she focused on was the need to keep green suitors (soldiers) in the development loop. She believes that soldiers that are educated in these technologies can save the Army money by writing code rather than trying to tell someone else what you want and then having the programmer write the code. She also believes that the national laboratories are a great source of assistance in developing these technologies and the Army should not just look to industry for help. She also thought that more cooperation between the Army and universities research departments would provide the Army some of the research required with less cost.

Ms. Ratzenberger felt that the role the Army will play in the future will most likely not change for several reasons. The first being the budget and the second is the

niche the Army has found in following industries lead in the development of these technologies.

MAJOR ROBERT REYENGA

PROJECT OFFICER, FUTURE BATTLE LABORATORY

Major Reyenga is a Project Officer at the Future Battle Laboratory, Fort Leavenworth, Kansas. This interview was conducted on 22 January, 1992 and was done in person. The primary focus of this interview was to receive the background information concerning the operation of the artificial intelligence cell at the at the Future Battle Laboratory. Additionally Major Reyenga provided insight into the future direction the Army may take concerning expert computer systems and artificial intelligence systems as related to the projects being conducted by the Future Battle Laboratory and the Army as a whole.

Major Reyenga stated that both expert systems and the other forms of artificial intelligence either play an important role in the Army today or will in the future. He divided the uses of expert systems into two separate categories for the purpose of the discussion and to provide examples of some success stories and other areas where the success are somewhat limited.

He said that those expert systems that provided maintenance diagnostic types of applications are very useful in industry today and the Army is beginning to take advantage of this type of technology. These forms of expert

systems could be produced in most cases for a shell rather than have a programmer start from scratch. The also spoke strongly of the Army's need not to duplicate any of the work already completed by the civilian community but rather to adapt those systems currently available to suit the needs of the Army.

An area of expert systems he did not believe offered much help, at least with the current technologies available, is in the area of command and control systems. It is in this area that Major Reyenga believes that decisions must be made by humans. This is not to say that there are not systems available that can do the various component parts of the command and control process because he knows there are. He sites an example of ongoing work at the Battle Future Laboratory attempting to consolidate the various battlefield operating systems into one system that can evaluate the information and provide the commander with information priorities and recommendations. The greatest problem, as Major Reyenga sees it, is the inability of the current technologies to display initiative.

He sees the Army's role in the future remaining much the same as it currently exists; a follower's role. He does not think this is bad but the Army must take advantage of all the proven things industry has developed and find ways to exploit their uses. He does not see the Army's commitment to these two technologies changing much even in the face of reduced dollars and manpower. He contends that

the Army must maintain the technological advantage in the next war and the only way to do that is to continue to advance in the areas of artificial intelligence.

MAJOR ROBERT RICHBOURG, Ph.D.

FORMER DIRECTOR OF THE OFFICE OF ARTIFICIAL INTELLIGENCE ANALYSIS AND EVALUATION

This interview was conducted on 22 January, 1992 and was done in person. The primary focus of this interview was to receive the background information concerning the operation of the artificial intelligence cell at the at the Artificial Intelligence office at the United States Military Academy at West Point, New York. Additionally Major Richbourg provided insight into the future direction the Army may take concerning expert computer systems and artificial intelligence systems as related to the projects being conducted by the Army as a whole.

Major Richbourg like the other three interviewees believes that the Army is really geared to the use of expert systems rather than the other types of artificial intelligence. He spoke of the education process in the Army and the various TRADOC schools that have artificial intelligence cells and the importance of the work they were doing to make expert systems more accepted by the Army. He stated that more work is being done by the air force than the Army in the area of neural networks but that some work was continuing at the national laboratories. He believes

that this particular field is not well developed and the Army should take a wait and see attitude. He stated that these types of artificial intelligence are not panaceas but may have some application in the future.

Major Richbourg repeated the same statement as did all of the interviewees with regards to the way the Army approaches these problem. The Army has a tendency to attack these problems from a technology aspect rather than from the problems we need to solve. His solution is to ensure you have smart personnel, whether they are military or Department of the Army civilians, evaluating the issues and not duplicating efforts.

With regards to the issue of the Army's follower's role changing in the future, he did not think it would. He thinks that the Army must get the biggest bang for its buck and the best way to do that is to have smart individuals addressing the various problems and determine the best solution for each situation. This may mean to use an expert system currently being used by industry, or perhaps designing a system from the ground up, or perhaps combining several different technologies.

The focus of Major Richbourg's remarks were that the Army must be smart in evaluating the technologies that currently exist and use them to our best advantage.

APPENDIX C

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